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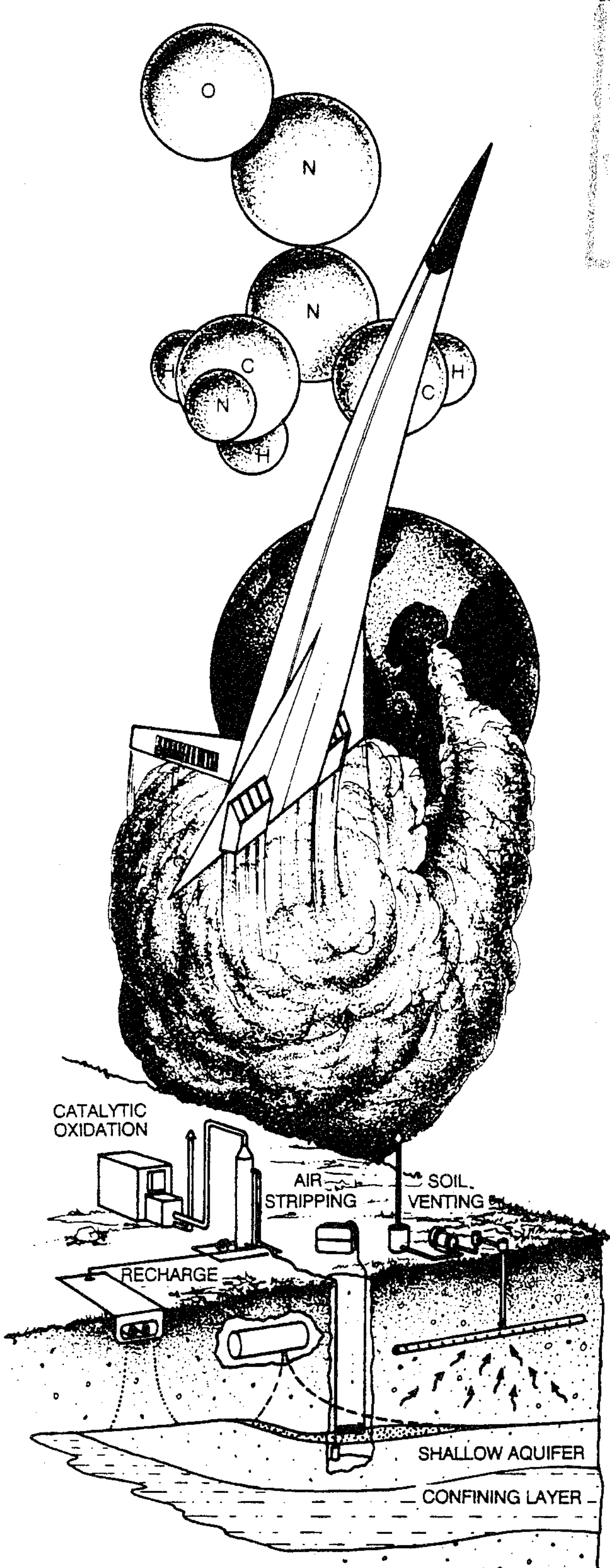

NONCYANIDE STRIPPERS TO REPLACE CYANIDE STRIPPERS

M.D. ARGYLE, R.L. COWAN, G.L. HUDMAN, T.A. CLOSE, R.V. FOX, G.A. HULET, J.L. SCOTT

IDAHO NATIONAL ENGINEERING LABORATORY
EG&G IDAHO, INC.
IDAHO FALLS, IDAHO 83415-2050

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M.D. Argyle, R.L. Cowan, G.L. Hudman,
T.A. Close, R.V. Fox, G.A. Hulet, J.L. Scott

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13. ABSTRACT (*Maximum 200 words*)
This report presents the results of an Idaho National Engineering Laboratory (INEL) study of three electrolytic silver strippers that were tested in addition to three new immersion nickel strippers. Two nickel strippers successfully completed field testing last year. Frederick Gumm's CELOP 204 and Electrochemicals, Nickel-Sol were placed in service in the plating shop at Kelly AFB July through September 1990. This research has yielded at least one formulation (containing ethylenediamine sodium m-nitrobenzenesulfate, nitric acid, sodium nitrate, and ammonium thiocyanate) worthy of field testing. The formulation is for stripping electrolytic nickel. Other formulations, especially those for stripping electroless nickel, need further investigative work. A by product of the field test stripping process above is redwater in the waste stream. An investigation was unable to identify the chemical species responsible for the colored water. The report recommends (1) that at least one generic nickel striper formulation be field tested, (2) one of the silver strippers (McGean-Rohco's Rostrip 999-SP) be implemented at the ALC, and (3) further attempts be made to discover the source of the redwater in the waste stream.

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EXECUTIVE SUMMARY

OBJECTIVE

The objective of the Noncyanide Strippers To Replace Cyanide Strippers Program (NCYS) is to reduce the use of cyanide-containing process solutions and the subsequent generation of cyanide bearing wastes from Air Logistic Command Centers (ALCs). The program addresses the selection of strippers and process enhancements related to noncyanide metal stripping. The technologies in place have been evaluated for the effects that replacement or alteration would have on both upstream and downstream processes. Our approach has attempted to ensure successful implementation of useful technologies by preserving or improving existing production rates, while simultaneously providing for waste minimization.

BACKGROUND

The program to replace cyanide containing metal-stripping solutions in the plating shop at Kelly AFB continued in an orderly manner. During Phase I (FY 88) an initial market survey was conducted as well as preliminary laboratory testing of commercial noncyanide stripping products. Laboratory testing of the strippers continued into, and was completed, during Phase II (FY 89). The laboratory testing of silver recovery techniques was also performed during Phase II. Field testing started during Phase II using nickel and copper strippers which had successfully passed the laboratory tests. The testing of copper strippers was discontinued after Phase II upon agreement with the Air Force. Variables such as pH, temperature, metal loading, and regeneration were tested and optimized during these field tests. The step beyond successful field testing was to implement the most worthwhile products into the plating shop at Kelly AFB. This leads into the scope of work for Phase III (FY 90).

SCOPE

In Phase III of the NCYS Program, several concurrent tasks were pursued. Field testing continued and, this year (FY 90), three electrolytic silver strippers were tested in addition to three new immersion nickel strippers. Two nickel strippers which successfully completed field testing last year (Frederick Gumm's CLEPO 204 and Electrochemicals' Nickel-Sol) were placed in service in the plating shop at Kelly AFB July through September of 1990. Work continued on the development of a "generic" nickel-stripping formulation. Several avenues of support work were also explored. At the request of Kelly AFB, research was conducted to identify and isolate the chemical species responsible for the intense red coloration of the waste discharge from the plating shop. Perhaps the most important support work involved the biological treatment of new noncyanide stripping solutions with particular emphasis on destruction of ethylenediamine (the active ingredient in CLEPO 204 and other noncyanide stripper formulations). The research into silver recovery was not pursued further this year. Other investigative support work was performed on fluid agitation systems and noncyanide metal cleaning solutions.

Three nickel strippers were field tested and include: MetalX's B-9 Nickel Stripper, M&T Harshaw's Ni-plex 100, and Enthone's Enstrip N-190. Of these, the first two are amino acid based and the last is an ethylenediamine-based formulation. B-9 nickel stripper showed the highest stripping rates at the higher temperatures and within the manufacturer's suggested pH range. Attempts at solution regeneration were extremely successful with stripping rates restored almost to the original values. Similar results were observed with Ni-plex 100, but the stripping rates were slightly lower, and the regeneration was not as effective. Tests with N-190 determined that it is similar, although slightly inferior, to the already implemented CLEPO 204.

The three silver strippers which were field tested are as follows (listed in order of effectiveness): McGean-Rohco's Rostrip Electrolytic Stripper 999-SP, Technic's Cy-Less Electrolytic Gold Strip, and Technic's Non-Cyanide Silver Stripper (Electrolytic). The only stripper that approached the same stripping rate as the cyanide process was Rostrip 999-SP (about 8 milliinch per hour), while the other two had significantly lower rates.

One excellent "generic" formulation was developed which shows a stripping rate for electrolytic nickel plates of over 2.5 milliinch per hour, a rate which is better than CLEPO 204. The formulation containing ethylenediamine, nitric acid, sodium nitrate, and sodium *m*-nitrobenzenesulfonate offers an excellent starting mixture which may be improved even further. The above formulation, with the addition of a small quantity of ammonium thiocyanate (chemically and toxicologically different from cyanide), yielded the above mentioned stripping rates.

The preliminary biological test results indicate that the IWTP at Kelly AFB contains microorganisms capable of degrading ethylenediamine found in commercial noncyanide stripping solutions. These microorganisms have been isolated, identified, and are not known pathogens. Although these microbe populations are present, currently their enzymatic pathways are not induced to degrade ethylenediamine. Further research will need to be performed to determine the acclimation time response, optimal treatment time, carbon loading capacity, carbon removal efficiency, and the byproducts of ethylendiamine degradation.

The studies on the red water revealed that a great number of possible species can be responsible for the coloration. We anticipated that the reaction between sodium *m*-nitrobenzenesulfonate and sodium cyanide in alkaline solution would yield perhaps 5 products. We later discovered that the reaction gave at least 25 chemical species as identified by HPLC analysis. Due to the myriad of products, we were unable to identify the chemical species responsible for the red coloration.

The tests for fluid agitation indicate that of the three systems tested, the one-nozzle manifold appears to work best. However, further testing would still be required before we could recommend implementation of a specific system.

CONCLUSIONS

Three new nickel strippers were field tested. Of these, MetalX's B-9 Nickel Stripper performed best for stripping of electroless nickel while Ni-plex 100 was close behind. Both products showed adequate protection of ferrous substrates. The Enstrip N-190 is very similar in composition to CLEPO 204, but is not as effective. Of the electrolytic silver strippers field tested, McGean-Rohco's Rostrip 999-SP was most effective at removing silver plates, and, since it contains only inorganic salts, is easily treated for waste disposal. Its problem lies in attack upon Haynes 188 and Inconel 718 basis metals. The other two were poor at stripping silver and one contains a suspected carcinogen (thiourea). The research into generic nickel-stripping formulations has yielded at least one formulation (containing ethylenediamine, sodium *m*-nitrobenzenesulfonate, nitric acid, sodium nitrate, and ammonium thiocyanate) worthy of field testing next year. This formulation is for stripping electrolytic nickel while other formulations (especially those for stripping electroless nickel) need further investigative work.

The preliminary biological destruction tests have yielded promising results, and more work needs to be performed before the optimal physiological parameters can be determined. This work will need further lab testing before the pilot-plant tests can be started. With luck, the work can be taken from the lab to the pilot stage in the following two years. Preliminary results indicate microorganisms are available which can degrade the organic components in the new noncyanide stripping solutions under existing conditions.

As previously stated, we were unable to identify the species responsible for the colored water. The one-nozzle fluid agitation system worked adequately for our tests, but would require further testing before implementation.

RECOMMENDATIONS

The implementation work completed this year (FY 90) should be distributed among the other ALCs. We have incorporated the appropriate documentation into Appendices Q & R. Of the three new nickel strippers tested during this phase, MetalX's B-9 Nickel Stripper is recommended for implementation with M&T Harshaw's Ni-plex 100 as alternate. Of the three silver strippers field tested during this phase, only McGean-Rohco's Rostrip 999-SP is favored for implementation. At least one generic nickel stripper formulation should be field tested next year and possibly implemented by the end of the fiscal year. The biological destruction capabilities of on-site waste treatment facilities must be further explored. The biological laboratory tests should be continued and carried through to pilot stage as soon as possible. The reasoning for this is that with the capability to biodegrade spent stripping solutions, the ALCs would be able to process spent noncyanide stripping solutions on-site. On-site treatment is favored over off-site disposal. We would recommend that further work be performed to identify the chemical species responsible for the "red water." Finally, fluid agitation is recommended to reduce maintenance and enhance noncyanide stripping solution lifetimes.

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PREFACE

This report was prepared by Idaho National Engineering Laboratory, EG&G Idaho, Inc., Idaho Falls, Idaho 83415-2050, DE-AC07-76ID01570, for the U.S. Department of Energy (DOE) and the Air Force Civil Engineering Support Agency (AFCESA), Suite 2, 139 Barnes Drive, Tyndall Air Force Base, Florida 32403-5319.

This report presents the results of an Idaho National Engineering Laboratory (INEL) study of three electrolytic silver strippers that were tested in addition to three new immersion nickel strippers. Two nickel strippers successfully completed field testing last year. Frederick Gumm's CELOP 204 and Electrochemicals, Nickel-Sol were placed in service in the plating shop at Kelly AFB July through September 1990. Research continues into the development of a "generic" nickel stripping formulation. This research has yielded at least one formulation (containing ethylenediamine sodium m-nitrobenzenesulfate, nitric acid, sodium nitrate, and ammonium thiocyanate) worthy of field testing. The formulation is for stripping electrolytic nickel. Other formulations, especially those for stripping electroless nickel, need further investigative work. A by product of the field test stripping process above is redwater in the waste stream. An investigation was unable to identify the chemical species responsible for the colored water. The report recommends (1) that at least one generic nickel striper formulation be field tested, (2) one of the silver strippers (McGean-Rohco's Rostrip 999-SP) be implemented at the ALC, and (3) further attempts be made to discover the source of the redwater in the waste stream.

The work was performed between Oct 1989 and Sep 1990. The AL/EQS project officer was Lt. Phillip Brown. EG&G project manager was M.D. Argyle.

This technical report has been reviewed by the Public Affairs Office (PA) and is releasable to the National Technical Information Service, where it will be available to the general public, including foreign nations.

This report has been reviewed and is approved for publication.

Phillip P. Brown

PHILLIP P. BROWN, 1LT, USAF, BSC
Environmental Engineer

Michael G. Katona

MICHAEL G. KATONA
Chief Scientist

Edward N Coppola

EDWARD N. COPPOLA, Maj, USAF
Chief, Environmental Compliance Division

Neil J. Lamb.

NEIL J. LAMB, Colonel, USAF, BSC
Chief, Environics Directorate

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SECTION I
INTRODUCTION

A. OBJECTIVE

The objective of the Noncyanide Strippers To Replace Cyanide Strippers Program (NCYS) is to reduce the use of cyanide-containing process solutions and the subsequent generation of cyanide bearing wastes from Air Logistics Command Centers (ALCs). The program addresses those technologies directly related to the testing and enhancement of noncyanide metal strippers. These technologies are being evaluated for their effects on upstream and downstream processes to insure minimal impact on both existing operations and the environment. This includes development and implementation of technologies which reduce wastes, generate treatable wastes, or generate wastes which can be disposed of in an environmentally compliant manner. This is the third phase (FY 90) of work to meet these goals. The previous work has been presented in the Phase I (FY 88) and II (FY 89) Final Reports (Refs. 1,2). The research and development effort continues to focus on the following generalized activities:

1. Test, evaluate and implement acceptable commercial noncyanide metal-stripping technologies.
2. Develop supporting technologies which will enable maximum production benefits to be realized from the noncyanide processes (e.g., fluid agitation, colored component identification, etc.).
3. Develop and demonstrate biological destruction capabilities to accommodate new generation process wastes using existing facilities.
4. Develop, test, evaluate, and implement new generic noncyanide metal-stripping formulations.

Our approach has attempted to insure successful implementation of useful technologies by preserving or improving existing production rates while simultaneously providing for waste minimization.

B. BACKGROUND

The United States Air Force (USAF) operates electroplating facilities (Ref. 3) in support of maintenance and overhaul of engine and airframe components. They combine the organization and efforts of skilled workers with literally hundreds of technologies and tens of thousands of process steps.

Cyanide solutions have been used to: strip plate metals and surface coatings from aircraft parts, clean and remove smut from parts in preparation for electroplating, and electroplate metals onto parts. Each of these solutions has a limited lifetime, requiring frequent replacement and disposal of the spent solutions. Seventy-five percent of metal finishing waste comes from metal-stripping solutions and contaminated rinse waters. Fifteen to twenty percent comes from plating solutions. Five to ten percent is contributed by solutions used in rust, scale, and smut removal. In addition, many of the process solutions generate a metal-bearing cyanide sludge during use.

The spent solutions are typically high in cyanide and metal concentration and require special treatment and disposal procedures. These solutions cannot be treated at the Industrial Wastewater Treatment Plant (IWTP) because of their toxic effects on the biological treatment system (because of this, these solutions have in the past been drummed and shipped off-site for land disposal). Most of the metals may be recovered from these solutions with standard technologies such as ion-exchange, precipitation, or sodium sulfide/ferrous sulfate precipitation (Refs. 3,4). Metals complexed to cyanide, however, are not easily removed from solution due to the strong complexing nature of the cyanide ligand, and solubility of the formed complexes. Therefore, the cyanide must be treated before metals recovery or biological treatment of any organics, that may be present in the waste water, can occur. The cyanide may be destroyed by using standard technologies which react the cyanide with chlorine gas or sodium hypochlorite in alkaline solutions (Ref. 5)

Cyanide strippers have been used commercially to strip a large variety of plate metals and other surface coatings from several different basis metals

and nonmetallic substrates. Years of reliable service and the accumulation of worker knowledge have led to a reluctance to replace these cyanide metal-stripping solutions with alternative noncyanide formulations. Yet, the Air Force is committed to removing cyanide processes from their operations.

The spent solutions and sludges containing cyanide are hazardous wastes and are a significant part of the total electroplating waste generated at the ALCs (Ref. 6). Human exposure to cyanide in any form poses great health risks. In addition to the health hazards, federal regulations are making it more difficult to dispose of the cyanide wastes. Specifically, the Resource Conservation Recovery Act (RCRA) precludes the practice of landfilling leachable or liquid cyanide wastes.

New noncyanide metal-stripping formulations and processes are being investigated and used by industry because of the increasing concern with worker exposure to toxic chemicals and the more stringent regulations governing hazardous waste treatment and disposal. Significant advances in metal-stripping technology in the last ten years has yielded numerous commercial noncyanide formulations for different plate metal/basis metal combinations. Several of these are now being used in large-scale industrial electroplating facilities.

The Air Force could benefit if these new technologies were implemented at ALC electroplating shops. Reduced use of cyanide products will result in reduced contact time for personnel to the associated hazards. Accordingly, the margin of safety of all personnel that handle cyanide during the course of their work will be increased. This includes a large number of people from initial contact for distributors to the final contact for waste treatment personnel. Additionally, replacing cyanide strippers with noncyanide chemicals will reduce the amount of cyanide entering the environment through spills, or from inefficient removal during the waste treatment process. The less toxic and more biodegradable noncyanide replacement compounds impart greater confidence in restoring the environment if spills or problems occur.

1. Phase I Activities

Phase I activities were completed in FY 88. A summary of those activities follows.

PHASE I TASKS:

- Developed a comprehensive knowledge of Air Force refurbishing processes that use cyanide solutions and generate cyanide wastes.
- Determined specific Air Force applications, i.e., plate metal/basis metal combinations exposed to cyanide solutions.
- Developed a comprehensive knowledge pertaining to noncyanide technology.
- Evaluated the state of the art in noncyanide metal-stripping technology.
- Obtained commercially available noncyanide metal-stripping products.
- Performed laboratory performance evaluation tests (tailored to meet Air Force performance requirements and waste minimization objectives) on commercial products.
- Provided a summary report to indicate the findings (Ref. 1).

2. Phase II Activities

Phase II activities were completed in FY 89. A summary of those tasks is given below.

PHASE II TASKS:

- Constructed a Stripper Field-Test Facility (FTF) at Kelly AFB.
- Obtained baseline data for cyanide stripping processes used in Building 301 at Kelly AFB.
- Completed laboratory-scale testing of commercial strippers not available for testing in Phase I.
- Initiated laboratory-scale evaluation of noncyanide silver-stripping processes and commercial formulations.
- Conducted field performance tests with the five commercial noncyanide metal strippers listed in Table 1.

- Investigated the fundamental processes that occur during metal stripping for nickel, copper, and silver.
- Performed laboratory-scale evaluation of commercial silver recovery processes to extract silver from waste solutions and sludges resulting from noncyanide silver strippers.
- Examined fluid agitation systems.
- Summarized the findings in a Phase II Final Report (Ref. 2).

TABLE 1. COMMERCIAL STRIPPERS FIELD-TESTED DURING PHASE II AT KELLY AFB.

Manufacturer	Product	Application
Circuit Chemistry Corp.	Cirstrip NCN-CU	Copper from steel
Electrochemicals	Nickel-Sol	Nickel and copper from aluminum and stainless steel
Patclin Chemical Co.	Patstrip Ni	Nickel from copper
OMI Int'l	Udystrip XPS-306	Nickel from steel
Frederick Gumm Chemical Co.	CLEPO 204	Nickel from copper and steel

3. Results From Phases I and II

a. Laboratory Performance Evaluation Tests

During Phases I and II of the program, 32 commercially available noncyanide strippers were evaluated in the laboratory (see Appendix A). Stripper solutions which met performance criteria for plate metal-stripping rate, basis metal protection, and were inherently biodegradable, were targeted for field-testing. The strippers that exhibited acceptable performance in Phases I and II are comprised of solutions high in mineral acid, contain large fractions of highly volatile components, or require electrolytic operating conditions. Although these conditions have been acceptable, as evidenced by the use of similar solutions in the ALCs, other products are available which perform better for the Air Force electroplating applications. Unfortunately these products were initially identified in Phase I and Phase II testing as being not readily biodegraded in the existing activated sludge at the Kelly AFB IWTP. To resolve this problem, and to insure waste minimization, we are pursuing biological field laboratory research and pilot-scale testing to

develop, demonstrate, and test biological treatment methodologies which will utilize existing wastewater treatment facilities. The expense and liability of transportation and burial of metal finishing wastes is reduced by using existing wastewater treatment facilities.

Three strippers demonstrated a stripping rate greater than 1 milliinch per hour for electrolytic nickel (plated according to Technical Order 42C2-1-7 procedures). These strippers include: Nickel-Sol, Patstrip Ni, and CLEPO 204. Two strippers which were originally tested for stripping of copper also yielded acceptable nickel-stripping rates and included Cirstrip NCN-Cu and XPS-306. These solutions all showed stripping rates greater than the Air Force Cyanide Immersion (C-106) process, which had a measured stripping rate just under 1 milliinch per hour for electrolytic nickel.

None of the materials tested could approach the average silver-stripping rate obtained in laboratory tests using the Electrolytic Air Force Cyanide (C-101) process. It is not anticipated that any noncyanide silver stripper will be able to approach the performance of the cyanide electrolytic stripper because no other formulation can duplicate the tenacity of cyanide to function as a complexing agent for silver. However, out of the 19 strippers tested for silver, 10 produced stripping rates greater than 1.0 milliinch per hour. This rate is roughly comparable to the rate obtained when testing the Air Force C-106 process (2.38 milliinches per hour). All 10 noncyanide formulations showed good protection of stainless steel; however, only 6 provided adequate protection of low-alloy steel (LAS). The formulations which did not provide adequate protection of LAS were acidic and assumed to lack additional agents needed for passivation of the metal surface (the process which prevents corrosion).

b. Field Performance Tests of Noncyanide Nickel Strippers

During Phase II (Ref. 2), five commercial noncyanide metal strippers and the Air Force C-106 process were tested in the Stripper FTF. All exhibited a wide range of performance characteristics. Not all characteristics were the same as those exhibited in the Phase I laboratory tests. The commercial strippers tested were Cirstrip NCN-CU (Circuit

Chemistry Corporation), XPS-306 (OMI International), Nickel-Sol Process (Electrochemical), Patstrip Ni (Patclin Chemical Company), and CLEPO 204 (Frederick Gumm Chemical Company).

c. Electrochemical Evaluation of Stripper Components

The electrochemical tests performed in the laboratory examined the behavior of several plate metals and basis metals in contact with aqueous solutions containing chemical oxidants, chelating agents, and corrosion inhibitors. This led to the identification of chemicals potentially useful in developing new stripping formulations.

d. Precious Metal Recovery

During Phase II, selected spent solutions and sludges obtained from the silver-stripping tests were subjected to several different silver recovery processes. Techniques tested to recover silver from sludges were: (1) dissolution of the solid using a solution of a strong chelating agent followed by electrowinning of the metal, and (2) reduction of the sludge with a fused-salt flux. Techniques tested to recover dissolved silver from spent stripper solutions were: (1) recovery of the silver as insoluble salts by precipitation from the solution, (2) recovery of metallic silver using solutions of sodium borohydride as a reducing agent, and (3) recovery of metallic silver by electrowinning after adjusting the pH of the solution.

Average recoveries calculated in terms of elemental silver ranges from about 87% to over 99% depending on technique. The lowest recoveries were achieved for the pH adjustment/electrowinning technique, while the highest were achieved for the borohydride reduction technique. The performance of the electrowinning process could be optimized through further studies to improve recoveries. These techniques could help alleviate waste disposal problems as well as improve process economics by recovery of silver for recycle.

This task was continued into Phase III, but difficulties were encountered while attempting to scale-up recovery techniques. This coupled

with the loss of the key investigator on the project and a lack of interest expressed by Air Force personnel, resulted in the suspension of this task.

e. Fluid Agitation

Metal-finishing process solutions require agitation to fully benefit from the chemical action attainable in process tanks. Agitation, or mixing, of the solutions: (1) ensures uniform distribution of chemicals in the tanks, (2) enhances mass transport of active ingredients to the part surface, (3) increases the deposition rate of materials during plating processes, (4) enhances mass transport of undesirable reaction products away from the part surface in stripping and metal activation operations, (5) enhances mass transport of various soils away from the part surface in cleaning operations, (6) facilitates rapid temperature equilibration in process tanks, and (7) ensures uniform temperature distribution throughout the tanks.

With the incorporation of noncyanide strippers into plating shop within the ALC complex comes an increased awareness to the benefits of fluid agitation systems. The use of this type of system can significantly reduce the amount of airborne organics (VOCs) and also reduces the amount of maintenance that is required for the stripping solutions. The option of incorporating filters into the system can also extend the lifetime of the solutions and increase effectiveness.

C. SCOPE

The scope of the NCYS Program has increased as a result of information obtained during Phase II research efforts. Earlier projections identified technology transfer and installation activities for tasks to be completed in Phase III. The expanded scope of work includes these previously identified tasks plus additional related tasks. The additional tasks are associated with problem areas concerning cyanide usage, alternative formulations, and disposal of their wastes.

During Phase III, field-tests conducted at Kelly AFB continued with emphasis on completion of testing nickel-stripping solutions. Based upon the field-test results, CLEPO 204 (Frederick Gumm) and Nickel-Sol (Electrochemicals) were selected and successfully implemented at Kelly AFB (July through September of 1990) with the support and cooperation of the plating shop manager and personnel. Commercial noncyanide silver-stripping solutions tested in Phase II, which had good performance characteristics, were field-tested in this phase.

Information and input from Air Force personnel indicated a preference to continue the development of generic noncyanide metal strippers rather than a continued search for and testing of new noncyanide metal strippers on the market. As a result, no new commercial noncyanide strippers were tested during Phase III. Instead, the emphasis was placed on the development of a generic noncyanide nickel stripper.

Some strippers with otherwise good performance characteristics were rejected for further testing in Phase I because they did not meet the initial biodegradation criteria. Many of the rejected strippers contained components which were ultimately biodegradable, but the microorganisms in the Kelly AFB IWTP activated sludge that are able to utilize the new carbon sources required a period of time for acclimation to the new food sources. Biological laboratory tests were performed to demonstrate the capability of these microorganisms to degrade ethylenediamine (a common ingredient in commercial noncyanide nickel strippers). A biological field-test facility was constructed at Kelly AFB IWTP with two objectives: 1) to demonstrate the technical feasibility of biodegrading ethylenediamine based strippers, and 2) to continue evaluation of other stripping solutions for biodegradation feasibility.

A study was initiated to investigate the "colored water" problem associated with discharged wastewater from the Air Force C-106 process. We attempted to identify the chemical species responsible for the red coloration and to discern applicable treatment processes (chemical and/or biological) for testing.

The potential benefits to be obtained from fluid agitation were investigated since it was acknowledged that the incorporation of noncyanide strippers could create a problem with emissions of volatile organic chemicals (VOC's), especially when used with air agitation. Our involvement included a vendor search and preliminary testing of the process.

Other support technology covered in this scope included a preliminary assessment of current technologies in noncyanide metal cleaners.

The tasks involved in Phase III are summarized below.

1. Developed Phase III Test Plan
2. Noncyanide Nickel Stripper Implementation
   a. Introduced two commercial noncyanide nickel strippers, CLEPO 204 and Nickel-Sol, into the plating shop at Kelly AFB.
   b. Generated the appropriate documentation for introduction and use of these strippers into other ALC plating shops.
3. Commercial Nickel Stripper Field-Tests
   a. Optimized operating conditions for noncyanide nickel strippers.
4. Commercial Silver Stripper Field-Tests
   a. Tested and demonstrated the applicability of commercial noncyanide silver strippers for use in Air Force processes.
   b. Demonstrated the waste reduction characteristics of the selected processes.
   c. Provided alternative processes that generate silver by-products amenable to economical recovery processes.
5. Generic Stripper Development
   a. Developed a generic nickel stripper for removal of the electrolytic nickel used in Air Force applications.
   b. Searched the literature for information to be used in the development of generic copper and silver strippers for Air Force applications.
6. Biological Waste Treatment R&D
   a. Designed a scaled down pilot facility of the Kelly AFB IWTP.
   b. Built the pilot facility, and a Biological Field-Test Facility at the Kelly AFB IWTP.

c. Performed experiments to determine if the current activated-sludge culture could degrade ethylenediamine.

7. Colored Waste Water Treatment R&D ("Red Water")
   a. Attempted to identify the colored water components as a prerequisite to designing procedures to hinder formation or chemically destroy the colored components.
8. Fluid Agitation Development
   a. Performed preliminary testing to determine the performance of several fluid agitation systems.
9. Noncyanide Cleaning and Plating Solution Assessment
   a. Assessed the current use of cyanide metal cleaners in the Air Force plating shops.
   b. Assessed the current state-of-technology for metal noncyanide cleaners used in electroplating applications.
10. Report Results
   a. Provided monthly progress reports for Air Force review of current status.
   b. Provided a final report, in Air Force format, including data, conclusions, and recommendations derived from the test results.

SECTION II
RATIONALE AND METHODOLOGY

A. PROGRAM APPROACH

The original purpose of the NCYS Program was to evaluate the Air Force's need for cyanide processes, then test and implement the technologies which would eliminate the cyanide wastes produced in those processes. Metal-stripping processes were targeted first over metal cleaning and plating processes for the following reasons: (1) stripping processes produce the largest volume of cyanide-containing, concentrated and dilute metal wastes; (2) stripping processes lead to high worker exposure to cyanide dusts, solutions, and sludges through maintenance activities; (3) noncyanide alternatives are more advanced for stripping applications, compared to other cyanide-using cleaning and plating processes; (4) there are many commercially available noncyanide stripping processes to evaluate; and (5) the alternative noncyanide stripping processes have the least potential of adversely impacting quality and efficiency during production. The noncyanide stripping products also contain ingredients which are less toxic and more susceptible to biodegradation than cyanide.

B. EVALUATING THE STATE OF TECHNOLOGY IN COMMERCIAL NONCYANIDE PRODUCTS

1. Cyanide Metal Cleaning and Plating Solutions

The state of technology for cyanide metal cleaning and plating solutions was evaluated during Phase III (FY 90). A vendor search was conducted to identify commercial noncyanide plating solutions available for use in electroplating operations. However, the focus was specifically geared toward evaluating noncyanide metal cleaners which would prepare low-alloy carbon steels for electroplating as effectively as do cyanide cleaners. The cyanide cleaner of particular concern was identified in Military Technical Order 42C2-1-7 as C-204; an alkaline desmutter (cleaner) composed of sodium

hydroxide and sodium cyanide. Two alternate cleaners C-201 and C-203 are also listed. Although these alternate cleaners are available, Kelly and Tinker Air Force Bases continue to choose the cyanide cleaner for their operations, suggesting that C-201 and C-203 did not meet their needs.

C. TESTING NONCYANIDE PRODUCTS

The procedure used to determine whether commercial products would meet the needs of the Air Force went through the following sequence of steps. These steps are given in a sequential fashion and are not meant to provide a historical overview of the program. For detailed information on when each test was run, which products were tested, and the results of these tests; please consult the Background section of this report or the Phase I and II Final Reports (Refs. 1,2).

The new products were first analyzed for contents; those with extremely toxic or obnoxious components were thrown out. At the Air Force's request, those strippers containing phenol were eliminated. After passing this first stage, each stripper was then prepared according to the manufacturer's directions and tested using solution volumes of 250 mL. This is what we call laboratory-scale or "jar" tests. At this point, only the best strippers were singled out for further testing using the larger volumes of 10, 15, 20 or even 100 gallons (37.8, 56.7, 75.6, and 378.4 liters). This is called the "field" test stage and was meant to bridge the gap between solution volumes used in laboratory (jar) tests with those that would be obtained using the stripper in the plating shop. Once a stripper has passed this sequence of tests, it would then be cleared for implementation into the plating shop.

This sequence of tests was meant to screen out those strippers which did not work well. This screening step saved the Air Force and its plating shops the expense of purchasing, and later disposing of large quantities of various strippers required for testing. This step also helped to avoid production delays which could arise from the dedication of a number of different stripping tanks for the testing of these strippers. This sequential testing provided a smooth transition from performing a large number of small volume

tests to only a few full-scale implementations of the superior products into the plating shops at Air Force facilities.

1. Field-testing of Noncyanide Strippers

Noncyanide strippers which performed well in laboratory tests were selected for field-testing. When a stripper passed the field-test stage, it would be incorporated into the existing metal finishing shop at Kelly AFB. The field-tests were meant to serve as an optimization step where operating parameters such as pH, temperature, metal loading, longevity, and regeneration could be determined. These tests also used solution volumes more comparable to those in use at the Air Force plating shop.

To prevent galvanic corrosion and localized pitting in the area where the coupon is attached to the cathode, the upper portion of the coupon was waxed down, including the area around the hole. Stripping rates were calculated, using coupon density, weight loss, and exposed surface area. Corrosion rates were determined by visual and microscopic inspection for corrosion, pitting and etching in addition to weight loss calculations. The stripping rates and pitting analysis were compared with those obtained on samples evaluated with the current technology used in the plating shop. This information was used for selection of a noncyanide stripper for implementation.

a. Commercial Noncyanide Nickel and Copper Strippers

Field-tests were initiated during Phase II (FY 89) and completed in Phase III (FY 90). The copper strippers completed testing during Phase II and are included here for historical reasons. Roughly 10 percent of the products tested in the laboratory met the technical performance criteria and could be considered for field-testing. These commercial immersion and electrolytic products contained a number of ingredients including: phenol, organic amines, and inorganic acids, bases, or salts. The commercial products containing phenol were rejected for toxicity reasons and at the request of Kelly AFB. Through support technologies, the remaining products can be used even though they have some acknowledged limitations. For example, the

commercial products containing ammonia release noxious vapors and are expensive and require time-consuming maintenance. This is also true for the organic amine (ethylenediamine) strippers, although to a much lesser extent. The ethylenediamine strippers were initially identified as being not readily biodegradable in the existing activated sludge culture at the Kelly AFB IWTP. The inorganic acid strippers absorb moisture from the air to become diluted and are only useful for parts made of stainless steel. The electrolytic stripping process aggressively attacks almost all metals, requires constant monitoring during use, and is therefore less desirable than an effective immersion process.

Eight noncyanide nickel and copper strippers were selected for field-tests. These strippers are Circuit Chemistry Corp., Cirstrip NCN-CU; Patclin Chemical Co Inc., Patstrip Ni; OMI Int. Corp., XPS-306; Frederick Gumm Chemical Co, CLEPO 204; Electrochemicals Inc., Nickel-Sol; M&T Harshaw Inc., Ni-Plex 100; Metalx Inc., B-9 Nickel Stripper; and Enthone Inc., Enstrip N-190. The strippers were mixed according to the manufacturers' specifications. The metal coupons selected for evaluation consist of electrolytic and electroless nickel plates, Inconel, Haynes, copper (where applicable), and an assortment of carbon and stainless steels.

Stripping solutions were prepared and operated according to instructions contained in technical bulletins obtained from the manufacturer. Optimizations utilized operating parameters suggested by the manufacturer with each parameter varied to determine effect. This was done to determine the optimal conditions by which the stripper would strip the specified plate metal(s) yet protect selected basis metals. The optimization process looked at the following parameters: pH, temperature, nickel loading, and solution regeneration.

b. Field-testing of Commercial Noncyanide Silver Strippers

Commercial noncyanide silver stripper field-tests were performed in Phase III. Three noncyanide silver strippers that performed well in the laboratory have been selected for field-testing, based on their abilities to meet the criteria established in Phases I and II (Refs. 1, 2). These

strippers include: McGean-Rohco, Inc., Rostrip 999; Technic Inc., Non-Cyanide Silver Stripper; Technic Inc., Cy-Less Electrolytic Gold Strip. The strippers were prepared according to the manufacturers specifications and the operating conditions were optimized for pH, temperature, and current density since all strippers were electrolytic. The metal coupons selected for evaluation consist of silver, Inconel, Haynes, and an assortment of carbon and stainless steels.

D. DEVELOPING SUPPORT TECHNOLOGIES

The approach adopted allows current technologies to be evaluated and implemented for either quick fixes or long-term solutions, as applicable, in relation to how well the technology meets current and projected needs. Five areas of new technology development, integrally related to the successful implementation of noncyanide strippers, are either underway or forecasted for initiation. They include new fluid-agitation system design and development, generic noncyanide metal stripper development, biological waste treatment capabilities, and colored wastewater treatment. These four areas of development are discussed below.

1. Generic Noncyanide Metal Stripper Development

There are two primary technical reasons for using cyanide in stripping solutions: (1) cyanide has the ability to change the electrochemical behavior of several metals, allowing them to be oxidized more easily and, thus, more easily stripped and (2) cyanide is a strong complexing agent which readily binds to the oxidized surface species and facilitates dissolution. The dissolution of metal occurs after the exposed surface has been oxidized from the zero valence state to a higher one. When the oxidized surface species is dissolved, a fresh metallic surface becomes exposed and is subsequently oxidized. Thus, a cycle is established wherein a clean metallic surface is repeatedly oxidized and dissolved. In developing noncyanide strippers, the electrochemical and chemical properties of the constituents affecting dissolution and solvation of the oxidized metal species must be carefully considered.

Laboratory investigations in Phase II examined the fundamental mechanisms involved in stripping processes. The purpose of the investigations was to determine the behavior of metal surfaces and ions in the presence of potentially useful alternative solvents, chelating agents, and known surface passivation agents. The chemicals selected for study included those deemed suitable for future commercialization as alternative stripping reagents. Laboratory formulations of these reagents are called "generic" strippers in this report. Such reagents will be composed of inexpensive compounds that are also successful stripping agents. Some of these compounds have already been studied by the electroplating and mining industries and are available as proprietary formulations from the respective companies. In addition, the Air Force has some specific stripping applications, such as removal of plated silver, that have not received much attention in the commercial sector. Therefore, significant development work in this area will be required.

A noncyanide silver stripper is needed which simultaneously performs well and produces a low-hazard sludge of a chemical nature that facilitates recovery. The task of developing noncyanide silver and gold strippers is therefore twofold; they must be technically and functionally acceptable and have a suitable recovery process.

Testing performed in Phase II showed that electrochemical techniques can be used to develop a generic stripper formulation. Advantages from this study are twofold. First, formulations specific to Air Force applications will be developed. Second, the cost of using these formulations will be low since the ingredients will be known and can be purchased individually in technical-grade, bulk quantities. Several classes of components are needed to generate a successful stripper formulation. These components include: (1) an oxidizing agent to remove electrons from the plate metal and render it soluble, (2) a complexation agent to physically transport the plate metal from the surface into the bulk solution, (3) pH adjusting agent to aid the oxidation and solubilization steps, and (4) corrosion inhibitors to prevent attack of the solution upon the basis metal.

Stripping formulations are complex. The oxidizing agents are aggressive toward most metals and sometimes more aggressive toward the part

than the plated coating. In addition, the chelating agents affect the oxidation properties of the plate metals and basis metals to different degrees. In most stripping formulations, the oxidizing agents and chelating agents are matched to impart a greater effect on the plate metal than on the basis metal, however, the basis metal is still typically susceptible to degradation. This accounts for the necessity for the inclusion of a corrosion inhibitor.

The corrosion inhibitor can function in several different ways to protect the part. It may provide competing pathways to slow down the degradative reactions at the solution/part interface (in which case, dissolution of the plate metal is also hindered). It may render the basis metal surface inactive to the solution components (this is desirable if the protection is not due to the formation of a barrier layer resulting from initial degradation of the part). It may also provide a protective coating on the basis metal surface through chemisorption. This later condition is the most desirable from a technical perspective since the plate metal-stripping rate is not appreciably affected. This is also the most difficult situation to achieve because of the specificity involved. A corrosion inhibitor which behaves in this manner and is used widely in the metal finishing industry is sodium *m*-nitrobenzenesulfonate (a few other aromatic organics are less frequently used).

Nitrobenzenesulfonates demonstrate effective corrosion-inhibition properties on most ferrous alloy surfaces and are a major component in Air Force cyanide stripping solutions. They are inexpensive, relatively nonhazardous, stable, and convenient to use in many applications. There are many competitive reactions in which they participate (e.g., complexation to metals, substitution reactions, degradation...etc.), with essentially no change in contribution to the waste stream Chemical Oxygen Demand (COD). In addition, one particular reaction generates an intense red-colored species that is not readily degraded with existing chemical or biological waste treatment processes. This same colored species is generated in even higher concentrations during alkaline chlorination processes used to degrade cyanides. This colored species poses a problem since it is not readily degraded in the waste treatment facility and yields a wastewater which meets

organic discharge limits but is too highly colored for discharge. Simply replacing cyanide solutions with others will not necessarily resolve the problem because many commercial formulations contain this proven inhibitor as a key ingredient.

In Phase III, literature was used to aid in the identification of formulations and active ingredients which have been shown to strip the desired plate metal while protecting the basis metal (Refs. 7-29). Electrochemical techniques were then used to screen a large number of chemicals in a short period of time for their attack upon plate and basis metals. The following electrochemical techniques were used because they are fast and produce substantially lower volumes of waste than standard jar testing (Refs. 30,31):

- Potentiodynamic Anodic Polarization provides a relatively rapid means for approximating the corrosion potential (E_{corr} or E_{0c}) and the theoretical corrosion rate.

- Tafel Plots provide a better approximation of the corrosion potential (E_{corr}) and the theoretical corrosion rate, but they can take longer to perform.

- Direct Zero-Current Potential measurements provide the most accurate means of determining the corrosion potential (E_{corr}), unfortunately, this technique may be time-consuming since it requires waiting for the electrode to reach equilibrium with the solution.

After the screening of the most effective stripper components was complete, mixtures of these chemical agents (formulations) were tested using the same electrochemical methods. An attempt was made to maximize the efficiency of these formulations before jar testing plate and basis metal coupons.

Mixtures which exhibited good theoretical stripping rates in electrochemical tests were jar-tested to determine the actual nickel plate stripping rate. Formulations which proved successful at stripping the nickel

plates were tested to determine their attack upon low-alloy steel (C4340). Formulations that performed well in these laboratory tests will be field-tested. These tests were conducted at 55°C (130°F), with minimal air purge, and continual stirring which is similar to process conditions currently acceptable in ALCs.

2. Biological Destruction Capabilities

Biodegradability and metals removal tasks are becoming increasingly important. The current method of drumming concentrated stripping wastes for disposal will not be acceptable in the future because of increased economic, safety, and long-term liability considerations. During all phases of the program, as testing of materials proceeds, suitable technologies for the treatment of rinse waters, spent process solutions, and waste sludges prior to disposal are identified or developed simultaneously to help ensure smooth implementation of the technologies without compromising production. These tasks are difficult to address in a general fashion because the existing ALC waste treatment facilities vary in design, capability, and capacity. These facilities were primarily designed to handle dilute waste streams from which heavy metals are precipitated and any organics are decomposed in an activated sludge complex. However, if the current method of treating dilute aqueous waste streams can be expanded to include stripping wastes, significant economic and safety benefits can be realized.

Laboratory studies conducted in Phase I (FY 88) and II (FY 89) took waste solutions from commercial formulations and tested them to determine if the existing activated sludge at Kelly AFB IWTP facilities was adequate to reduce harmful effluents below National Pollution Discharge Elimination System (NPDES) limits. These tests indicated that some stripper components enhanced stripper performance but were not readily decomposed in the existing activated sludge system. Ethylenediamine was among these components.

Laboratory work was conducted in Phase III (FY 90) to: (1) determine if the IWTP activated sludge culture was currently biodegrading the targeted organic chemicals (6-hour test). If not, then (2) allow the microorganisms, which have the inherent ability to degrade the new carbon sources, the time to

acclimate to the new carbon sources present in these noncyanide strippers (72-hour test), and (3) isolate microorganisms from the acclimated culture which are able to degrade the targeted substrate. These microorganisms would be (4) identified to ensure that they are not enteric pathogens. The next series of tests targeted for completion in Phase I of the new Air Force program Demonstration Of Noncyanide Metal Strippers (FY 91) involves bench-scale bioreactor testing. In these tests the effects of pH, substrate composition, substrate concentration, and treatment time on the biological activity and treatment efficiency will be determined. Also, microorganism population distributions, and substrate decomposition byproducts which directly effect effluent quality will be determined (e.g., excessive nitrates, ammonia...etc.).

Data and recommendations gained from the laboratory studies will be used to justify pilot-scale studies. The purpose of pilot-scale studies is to confirm that the technology is feasible on a larger scale and that an activated sludge treatment system can be established which can biodegrade spent stripping solutions using the current IWTP wastewater matrix. Tests would be conducted to determine: (1) carbon loading capacity, (2) carbon removal efficiency, (3) optimal bioreactor configuration (e.g., one large reactor versus two smaller reactors in series), and (4) optimal treatment time.

This approach is suitable for other metal finishing waste streams, paint stripping wastes, degreasing and cleaning wastes, and for the general degradation of multiple organics present in typical industrial wastewaters.

3. Colored Wastewater Treatment

At the start of this program, the principal sources of the "red water" were the wastes generated in metal-stripping operations using the Air Force C-106 process. The C-106 process is designed to strip nickel, copper, silver, and other coatings from ferrous alloys at 55°C (130°F). It is composed of aqueous solutions of sodium cyanide, sodium hydroxide, and sodium *m*-nitrobenzenesulfonate. Upon initiation of this program, the contribution to

generating "red water" from the individual make-up components or the metals was unknown.

The rationale followed was to first determine which components and metals were essential to generate the "red water." Subsequent testing and analyses would then be performed on those "simplest" solutions for the purpose of identifying the compounds formed, and specifically, those contributing to the "red water." It may be necessary to identify all of the compounds, since each may potentially contribute to the effluent COD even though they may not have an associated color. Ultimately, the COD and red color must both be decreased to meet existing NPDES limits. To determine which initial components are necessary for the generation of the "red water," laboratory tests would be conducted with solutions of the make-up components; one at a time, in binary mixtures and, with all of the components present. If these solutions failed to give any appreciable color, metal-stripping tests would then be conducted in C-106 solutions using different plate and basis metals.

Standard laboratory techniques would be used to separate, isolate, crystallize, and identify the components present in solutions of the "red water". Chemical techniques for cyanide removal, precipitation of acidic organic compounds, and standard extractive procedures were to be followed as an initial method for reducing the complexity of the solutions and separating the ionic organic compounds from the neutral species. The fractionated solutions would then be subjected to instrumental analyses utilizing one or more of the following techniques: High Performance Liquid Chromatography (HPLC), Gas-Phase Chromatography (GC), GC-Mass Spectroscopy (GC-MS), Optical Spectroscopy (IR, UV-Vis, and Raman), and Ion Chromatography (IC).

It was hoped that by identifying the species responsible for the coloration, alternative methods could be identified to: prevent formation by substitution of key ingredients in the process, degrade the colored components by chemical or biological means, or provide inhibitory action to the process by chemical or physical means. These assessments would be made by drawing upon existing information regarding commercial waste treatment processes or, where no information existed, relying on the known chemistry of the individual components and the metal-stripping process.

4. Fluid Agitation

Specific types of agitation can impart different effects to the process. Air agitation, or sparging air through the solutions, provides generally efficient agitation, introduces oxidant (oxygen from the air) to the solution, introduces carbon dioxide to the solution, and provides a mechanism by which heat can be removed from the solution to the atmosphere during processes that evolve large quantities of heat. In addition, air agitation systems utilize low-cost, low-maintenance, chemically resilient materials that can be placed in effective orientations within the process tanks. This is the principal form of solution agitation used by the Air Force in metal finishing operations.

Introducing oxygen to solutions is beneficial in cyanide metal-stripping processes, but is generally unnecessary in noncyanide metal-stripping processes. In addition, a definite adverse impact occurs when oxygen is present in metal deposition baths. Carbon dioxide is rather innocuous in most acidic baths but significantly decreases the operating lifetime of alkaline baths, particularly, cyanide silver baths. In some instances, the trapping of air in concealed surfaces and pockets in the part causes the displacement of solution to the point where the desired chemical action is not achieved. Another adverse condition occurs in process baths that contain nonionized chemicals. Volatile emissions containing flammable, noxious, toxic, or otherwise hazardous organics and mineral acids are released from the solutions and contribute to high-volume atmospheric discharges and to generally smelly and corrosive work environments. In addition, when high flow rates of air are passed through process solutions, considerable cooling occurs. This, in turn, drives up the cost of operating any baths designed for operation at elevated temperatures.

Impeller-, or propeller-driven agitation systems provide significantly less effective agitation, but are necessary in some solutions for the above reasons. Noncyanide organic-based metal-stripping and cleaning solutions, electrodeposition solutions, electroless deposition solutions, and pickling baths are representative of the types of solutions requiring non-air agitation that make use of impeller agitation. The problems encountered with

impeller agitation are principally related to equipment drawbacks and placement limitations. Typical metal finishing solutions are highly corrosive and preclude the installation of submersed hardware that will require frequent maintenance or that can be ineffective if a part falls off a parts rack and jams the operation of the drive mechanism. The resulting limitations require impellers to be placed at the top of process tanks where they are easy to maintain, but where they offer the least effective agitation and impede the immersion and withdrawal of parts from the solutions. The principal reason for ineffective agitation for this placement arises from significant baffling of the directed fluid stream by parts immersed just below the surface.

Commercial agitation systems that differ in design are available for immersion in metal finishing baths, but suffer from several of the drawbacks encountered in impeller systems. Those models having the greatest potential usefulness in ALC operations are "hang-over-the-side" systems that draw the working solution into shielded impeller chambers and direct the outflow into the bulk solution at several exit ports staggered to differing depths of the solution. Agitation of the solution is generally very good close to the liquid exhaust ports and in unhindered or unbaffled regions of the tank. Unfortunately, in baffled regions, the solution agitation is very poor and the parts responsible for baffling the liquid jet are often subject to the full force of the jet and sway precariously in the tank. Another drawback is encountered as a result; that is, the mass transport at the part surfaces vary significantly and are impacted in direct proportion to the jet velocity. Thus, part surfaces exposed to the fluid jet receive the full impact of the chemical action possible from the solution, while concealed surfaces or surfaces on the back side of the part exhibit very little change. As a result, process tanks in excess of a few feet long can not be effectively utilized and considerable operator intervention is required throughout the process in manipulation of the part.

The hardware configuration used in air-agitation systems offers the most desirable operating characteristics for a large number of different types of metal finishing baths. Our developmental efforts in designing and developing a new, useful, and more applicable agitation system began with this

basic system design. Subsequent changes in the hardware and fluid drive mechanisms were incorporated and tested in this phase of the program.

Further technical development of fluid agitation systems is needed for currently used metal plating, stripping, and cleaning solutions and, more importantly, for new generation formulations being incorporated into ALC operations. The system under development and reported herein, has been designed to incorporate those features imparting the best mixture of: (1) mechanical ruggedness, (2) infrequent and minimal maintenance, (3) high reliability, (4) low operating cost, (5) efficient and effective agitation, and (6) the potential for further development incorporating automated cleaning and solution maintenance capabilities. These features will ensure successful implementation of the finished product and wide applicability for all types of metal finishing solutions.

The development of a suitable fluid agitation system having the above listed characteristics must necessarily progress through several stages. A description of these developmental stages follows. They are discussed in this text for completeness but it is noted that complete development of the system is not within the scope of this phase of the program.

The development of a fluid agitation system suitable for present and future ALC needs began with the acknowledgement that existing systems in operation were not performing at a high level of efficiency. Several designs received a cursory evaluation which led to integrating various hardware components and operation concepts, whereupon, a simple prototype system was constructed to meet the basic requirements of fluid agitation. The prototype was designed to provide agitation by means of directing liquid jets of working solution from the bottom of a process tank upward to impinge on the submersed parts. This basic design provides the greatest potential for bulk solution agitation with the corresponding least amount of energy input. Specifically, this design enhances the uniform mass transport of solution at all of the submersed part surfaces without creating pockets of high or low activity, respectively. It also minimizes the baffling effect created by large parts or crowded process tanks, minimizes the swaying and otherwise uncontrolled movement of parts, is not significantly reduced in efficiency as sludges

and/or parts accumulate in the bottom of the tank, and leaves the exposed surface of the solution and edges of the tank unencumbered by bulky hardware components.

The basic system is composed of a fluid pump, pump drive motor, piping to the tank, a manifold imbedded with nozzle jets, and a return line from the solution to feed the pump. Within the context of this equipment, many options are available in the choice of materials construction, sizing flexibility, configuration, and potential to modify or increase the sophistication of the system to incorporate filtering, air addition, maintenance chemical addition, and solution cleaning components.

Initially, a prototype system will be constructed which is suitable to meet the requirements of noncyanide metal stripping. Recommendations will be made following the tests for direction in future developments.

E. DEMONSTRATING AND IMPLEMENTING USEFUL TECHNOLOGIES

The NCYS Program will not be complete until useful technologies which will meet the program objectives have been implemented. In this phase of the program the knowledge obtained in the previous phases will be evaluated, useful technologies selected, an implementation plan assembled, and the processes implemented as a joint effort with the Air Force base personnel. These technologies will be used to handle part or all of the workload normally handled by the original processes, and will be introduced in a 1- to 3-month transition period. This will allow the Air Force base personnel to familiarize themselves with these new processes under actual working conditions, while causing minimal impact on normal workloads.

1. Implementation of Commercial Noncyanide Strippers

At the request of the Air Force, implementation was performed as soon as a stripper formulation successfully completed field-testing, rather than waiting for the completion of field-testing on the entire set of strippers. This was done to rid cyanide from the plating shop as soon as possible since

the products were already of proven capability from both laboratory and field-tests.

During Phase III (FY 90) two commercial noncyanide nickel strippers were put into practical service within the plating shop at Kelly AFB with the assistance of the plating shop personnel.

SECTION III
FACILITIES AND PROCEDURES

A. FIELD-TEST FACILITIES

1. Stripper Field-test Facility

The nickel and silver stripper tests were conducted in the field-test facility constructed south of building 301 during Phase II (refer to Reference 2 for further information including a floor plan).

2. Biological Field-test Facility

A field-test facility for the biological testing was constructed west of the Kelly AFB IWTP (building 621) February through April of 1990. The facility consists of a laboratory support trailer and a pilot-plant (a 1/32 scale replica of the IWTP biological treatment processes). The laboratory support trailer houses an office, a laboratory, and an instrument room. The pilot facility houses the pilot-plant and a control room which doubles as a storage room. Figures 1 and 2 illustrate the pilot-plant design and the engineering design, respectively, of the pilot facility.

a. Laboratory Support Trailer

The office provides space for data management, reference materials, and safety equipment. The laboratory houses the analytical instruments, scales, chemicals used in the laboratory, fume hood, and other smaller laboratory equipment needed. The instrument room contains the flammable solvent cabinet, two storage shelves, and other bulky equipment which is unable to be placed in the laboratory proper.

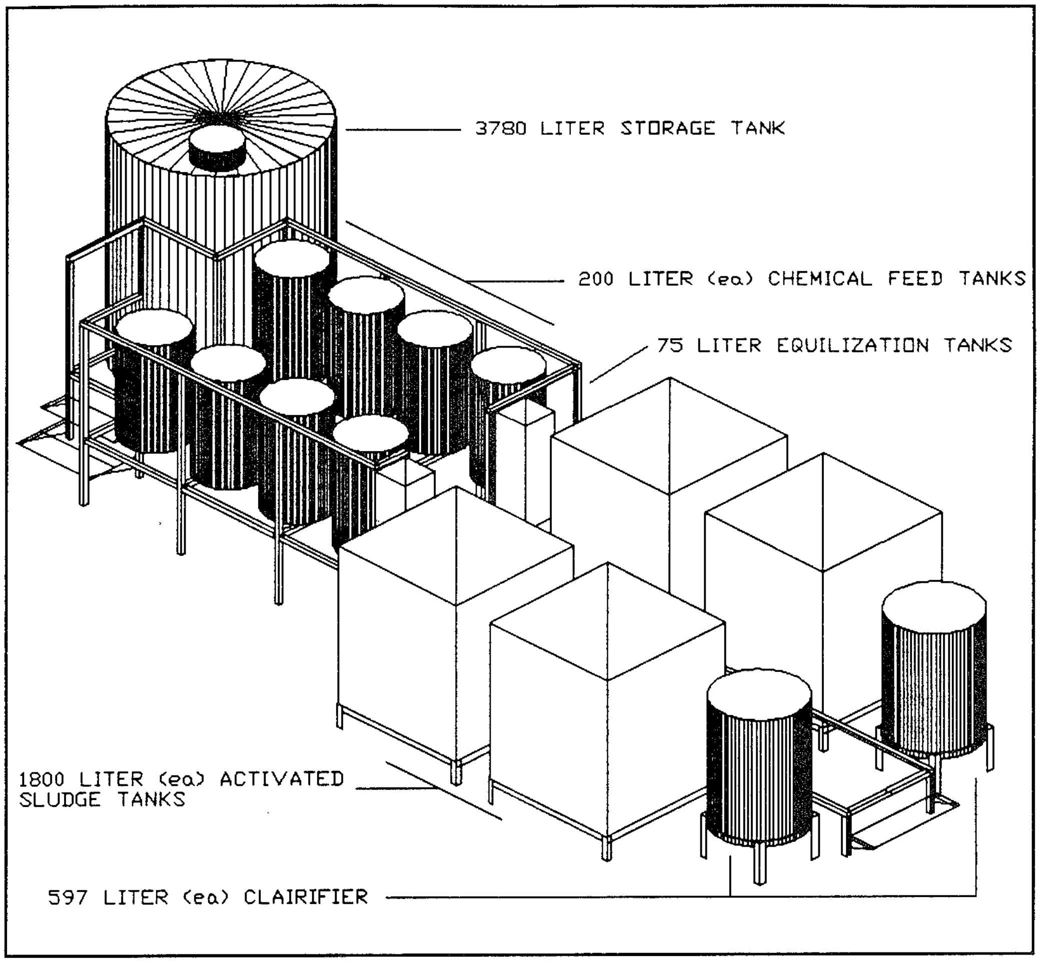

Figure 1. Pilot-Plant Design.

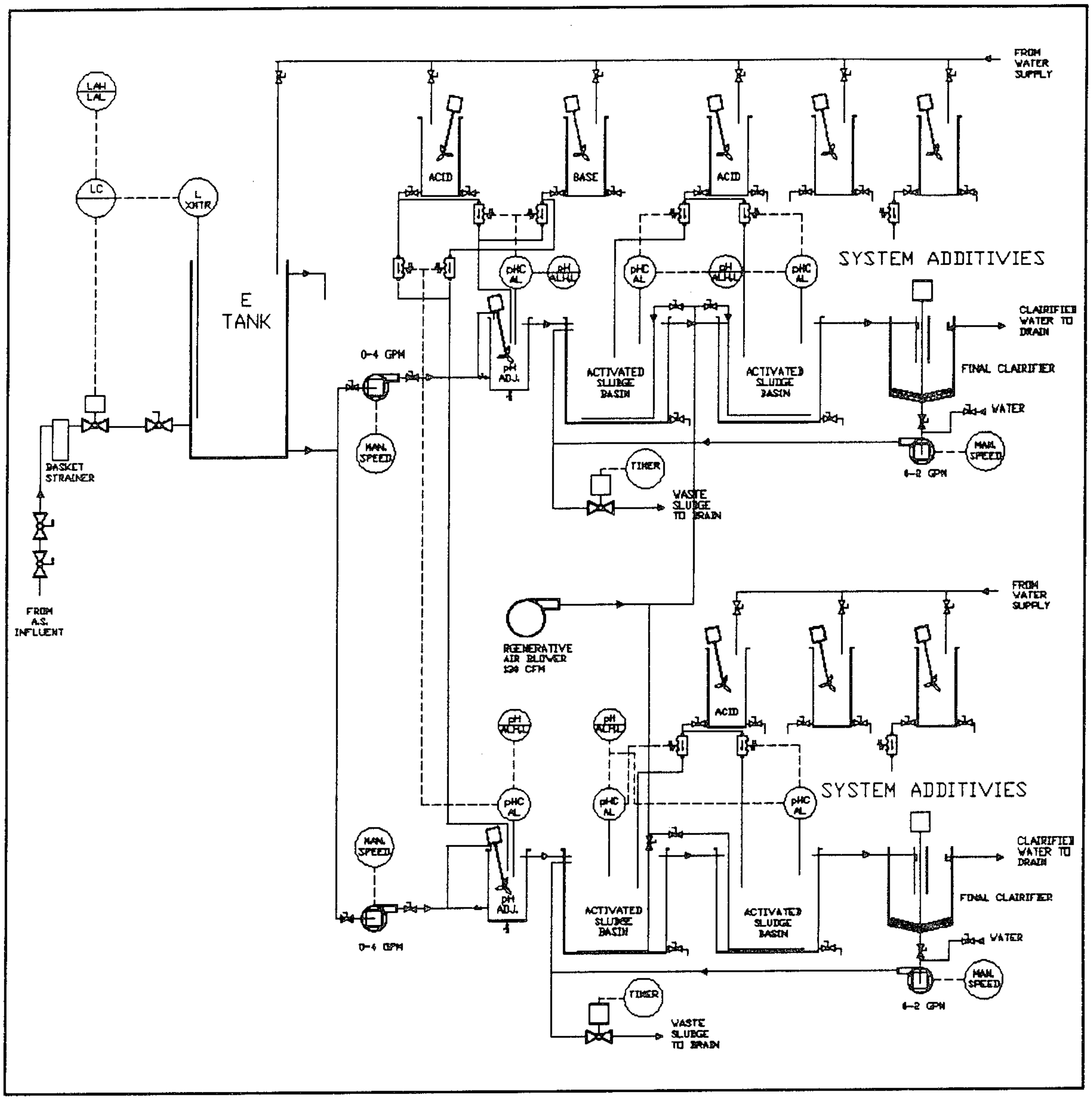

Figure 2. Pilot-Plant Engineering Design.

b. Pilot-Plant Facility

The pilot-plant facility is located 60 feet north of the laboratory trailer and is housed on a burmed concrete pad protected on three sides by a metal shed (north, west, and roof). The pilot-plant receives process water (under pressure) directly from the IWTP activated sludge influent, and feeds into a 3780-liter storage tank. The pilot-plant has two independent process trains each consisting of: a speed controllable process water influent pump capable of delivering up to 900 liters/hour of process water; four 200-liter chemical feed tanks complete with either automatically controlled pump feed, or manually adjusted pump feed for either pH control or chemical supplementation of the influent process water; a 75-liter equalization tank where the influent pH is controlled automatically, and process water chemical supplementation can take place; two 1800-liter activated sludge tanks in tandem; and, a 597-liter clarifier. The activated sludge tanks are aerated using a 125 ft^3/minute blower (24.5 liters/minute) which delivers air to the sludge through a network of porous PVC pipes. The clarifiers contain sludge wasting and recycle pumps and drain either sludge or process water back into the central IWTP. The control room houses the controls for the influent pumps, the sludge recycle pumps, the air blower, and also contains two storage shelves.

c. Laboratory Test Facility

Some biological laboratory experiments were conducted at the Idaho National Engineering Laboratory (INEL) while the Kelly AFB IWTP field-testing facilities were under construction and equipment for the facility was being ordered.

B. IMPLEMENTATION TEST PROCEDURES

1. Implementation of Nickel Strippers

Aircraft engine parts coated with electrolytic nickel, electroless nickel, or nickel-cadmium were used to evaluate the strippers. Stripping

evaluations of metal coatings removal were coordinated with an Air Force chemist at the plating shop. The work consisted of selecting representative parts, recording all pertinent parts information, and conducting the stripping evaluations. The operating volumes used for these strippers were 100 gallons (378.4 liters) for the Nickel-Sol stripper, and 660 gallons (2497.4 liters) for the CLEPO 204 stripper. All stripping process tanks were compatible with the strippers and were equipped with cross-flow ventilation. The commercial strippers evaluated consisted of multiple components which were mixed with water in accordance with the manufacturers product bulletin. Solution agitation was by use of an air-sparge system for the Nickel-Sol stripper, and a mechanical system for the CLEPO 204 stripper. Solution temperature for the CLEPO 204 stripper was maintained by use of a thermostated coiled steam heater. The Nickel-Sol stripping solution was used at ambient temperatures. Parts were processed using the Air Force cleaning and rinsing processes currently in use in the plating shop (building 301). Immersion exposure of parts consisted of either loading the small parts in stainless steel wire baskets or suspending the large parts from stainless steel hooks.

The aircraft engine parts were inspected every 1 or 3 hours for evaluation of stripping performance. The one-hour inspections were used for the Nickel-Sol acidic stripper, which has a higher stripping rate, and the 3-hour inspections were used for the CLEPO 204 stripper, an alkaline stripper. When stripping was completed, the parts were evaluated with respect to stripping and rinsing properties. The parts were then put back into the production line process and were reevaluated, after the cleaning process, for basis metal surface quality. The loading capacity of the strippers was determined by prolonged solution usage until the point of ineffective stripping ability was reached. At this point, the stripper was regenerated for continued use. Strippers which cannot be used indefinitely were regenerated until no longer effective. This length of time is termed the stripper life expectancy. Data obtained for each stripper evaluation was used to determine the economic benefits of using noncyanide strippers as opposed to cyanide strippers. The implementation results section of this study shows the benefits with respect to stripping rate, basis metal protection, worker safety, and disposal.

C. FIELD-TEST PROCEDURES

1. Immersion Nickel Strippers

Nickel and copper strippers were field-tested using operating volumes of 15 or 20 gallons (56.7 or 75.6 liters). The solution temperature was maintained using thermostat-controlled quartz heaters while the solution was agitated either mechanically or with an air sparge. The noncyanide metal strippers were prepared and used in accordance with the respective manufacturers product bulletin (Appendix B). Metal-stripping formulations generally consist of one or more components which are mixed with water to prepare the operating solution. The stripping rate for each stripper was determined using metal-plated coupons which were immersed in each stripper under various test conditions. Variables such as time, pH, temperature, loading capacity, and regeneration schedule were used in the evaluation process. Regeneration tests were not performed on strippers such as Enstrip N-190 and Nickel-Sol which provide for regeneration as part of the normal solution maintenance procedures. Basis metal protection was determined using various types of ferrous and nickel alloy coupons. This activity required chemical analyses for determination of the concentrations of stripped metals and maintenance chemicals. This consisted of standard laboratory titration tests such as pH and redox determinations. Metal concentrations were obtained using atomic absorption methods. Some additive chemical concentrations were determined by visible or ultraviolet spectrophotometric methods.

Test coupons of either basis or plate metals were cleaned by immersion in a 1,1,1-trichloroethane bath maintained at 60°C (140°F), then rinsed with acetone. The coupons were then placed in an oven at 80°C (175°F) for 30 minutes to dry completely, and subsequently cooled to room temperature in a desiccator. The weight of each coupon was measured to the nearest tenth of a milligram (0.0001 gram) using a Sartorius analytical balance.

Before processing, the coupons were firmly fastened to the end of a 3/16 inch by 30 inch threaded rod. The rods were then mounted on a holding rack. The area of the coupon to be exposed to the stripping solution was then taped with 1 1/2 inch wide masking tape. The coupon and rod were then

immersed in a hot wax tank, containing Petrolite BEE Square 175 Amber masking wax, to within about 1 inch of the holding rack. The immersed portion was allowed to remain in the wax until the coupon reached bath temperature, then removed and allowed to cool. Subsequent quick dips into the wax tank, followed by cooling cycles, were then made to build up the thickness of the wax coating. The surface of the coupons to be tested was then exposed by removing the masking tape. This area was then cleaned using 1,1,1-trichloroethane soaked cotton swabs, again followed by an acetone rinse.

The stripping tests for plate metals used immersion times of 1, 2, and 4 hours, while basis metal corrosion tests used a 24 hour exposure. At the end of each test, the coupons and rods were rinsed with water and the coupons were dried with paper towels. The coupons were removed from the rods, cleaned in the trichloroethane bath, rinsed in acetone, and placed in an oven at 80°C (175°F) for 30 minutes. The plated coupons which developed a heavy smut during the stripping test were cleaned by soaking for 15 minutes in 30 percent (by volume) hydrochloric acid and then wiped with a light abrasive soaped cloth. After rinsing in water and drying with a towel, the coupons were rinsed with acetone and dried in an oven as before. After removing from the oven, the coupons were placed in a desiccator to cool before weighing. After obtaining each coupon's weight, the surface was analyzed using a metallurgical microscope. Changes in mass and surface characteristics were recorded to determine the performance characteristics for each stripper as reported in the results section of this report.

The strippers were tested at temperatures which ranged above and below the recommended values provided by the manufacturer. The upper limit of the temperature range was 60°C (150°F), which is the maximum temperature allowed by the masking wax. The nickel strippers that were field-tested were directed towards stripping of electroless nickel and generally stripped better at the higher temperatures.

The pH optimization started with testing at the value recommended by the manufacturer. This was usually followed by testing one pH unit higher and lower unless information from the manufacturer suggested a narrower test range. In some extreme cases, another pH unit was tested beyond that. The

results were graphed to yield the optimum pH range that provided excellent nickel-stripping rates, yet did not sacrifice basis metal protection.

In the loading tests, sulfur-containing nickel anodes (S-Rounds) were immersed and eventually dissolved into the solution. The effects of nickel loading on stripping efficiency was then tested by evaluating test coupons at regular intervals [either 0.5 or 1.0 oz/gal nickel (3.75 or 7.5 g/L)] until the stripper was spent. Meanwhile, the test solutions were maintained and monitored according to manufacturers' instructions (Appendix B).

2. Electrolytic Silver Strippers

Electrolytic silver-stripping tests were performed using the apparatus shown in Figure 3. This was considered a field-test since the strippers underwent optimization for pH, temperature, and current density while the 1.2 liter solution volume was greater than that used in the laboratory tests last year. The solutions were mechanically agitated using a magnetic Teflon®-coated stir bar and a magnetic stirring plate. All tests were run using the 1:1 cathode to anode ratio as shown with one exception. The stripping rate versus applied current/voltage tests were done using a 2:1 cathode to anode ratio. This change was advocated to ensure uniform charge density on each silver coupon.

Counter electrodes were made with 321 stainless steel coupons as per the stripper manufacturers recommendations. Counter electrodes were assembled using 300 series stainless steel wire, screws, and mated nuts. An alligator clip was attached to the free end of the wire. The alligator clip was then clipped to the bus bar to provide good conductivity to the counter electrodes during testing.

The counter electrodes were cleaned and passivated in accordance with the standard procedure ASTM D 2688-83. The counter electrode surface was immediately reduced after the electrolytic process began, as observed in Figure 3. However, this procedure has proved, experimentally, to produce a uniform solids buildup at the cathode, and yields consistent results. The

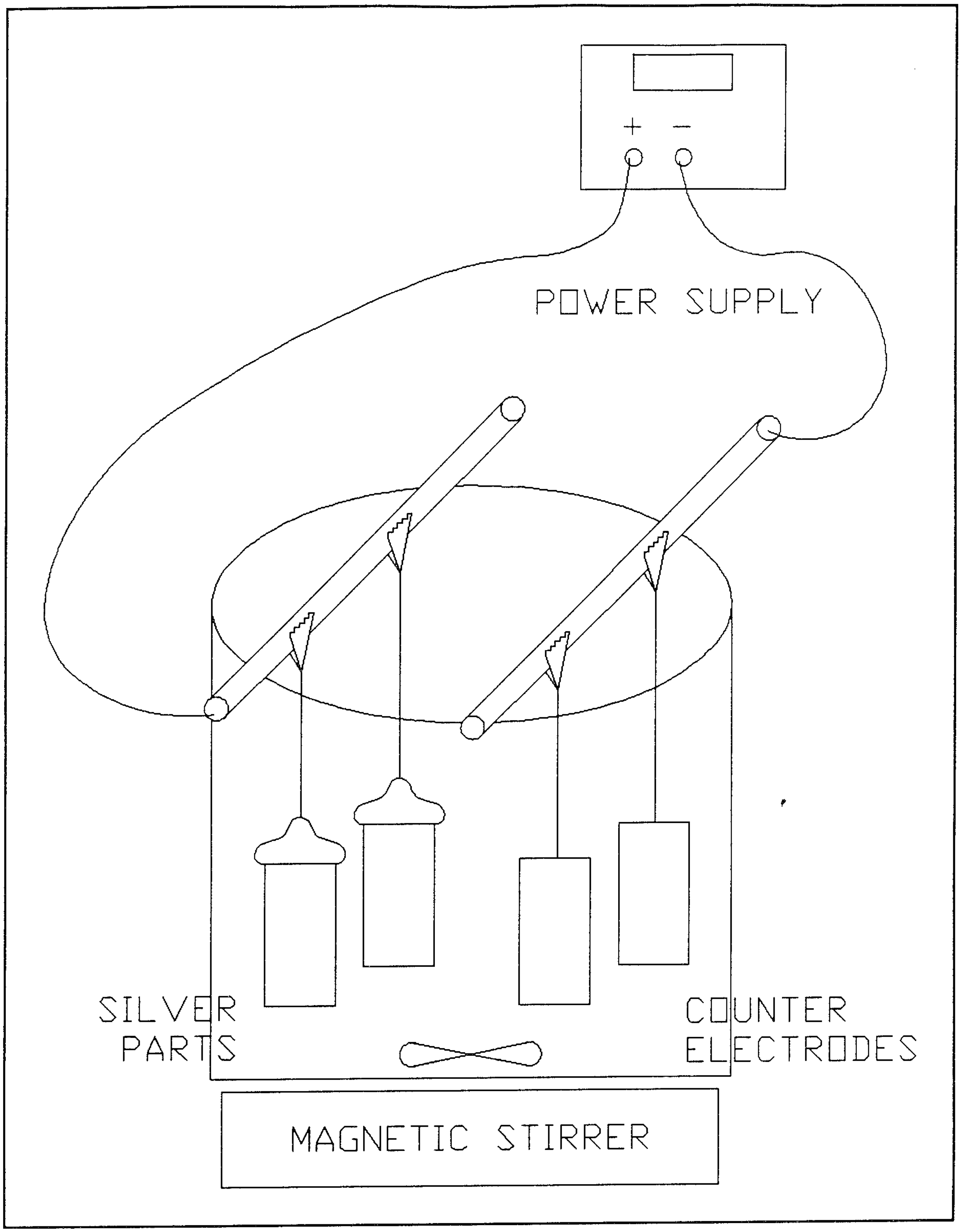

Figure 3. Electrolytic Stripping Apparatus.

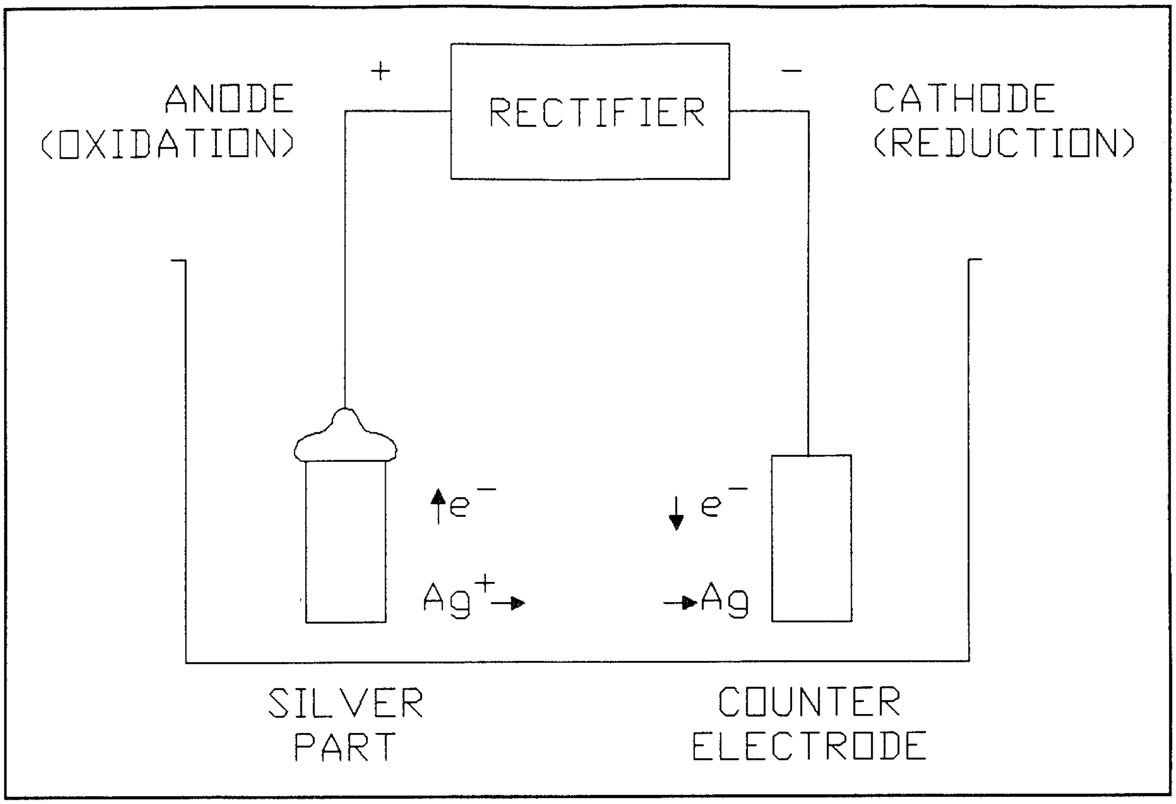

Figure 4. Electrolytic Stripping Reactions.

counter electrodes were removed after each test and replaced with fresh ones. This was done to provide constant charge density for each counter electrode.

Coupons selected for evaluation consist of silver and an assortment of carbon and stainless steel basis metals. These basis metals represent those from which silver is stripped in the Air Force plating shops. These include: D6AC, C4340, 316 SS, 410 SS, I-718, 17-4PH, and HA 188.

The basis metals and plate metal coupons were prepared for testing in the following manner. The coupon width and thickness were measured at three different locations to obtain average coupon dimensions. The average value was recorded. The coupons were scrubbed with soap and water using a nylon bristle brush, rinsed with distilled water, and acetone dipped. At this point the coupons were handled with nonmetallic tweezers to avoid fretting the coupon surface by metal-to-metal contact, and to avoid contaminating the

coupon surface with fingerprints and other soils. The coupons were then immersed in a beaker of tetrachloroethylene at a temperature of 66 ± 3°C (150 ± 5°F) for 2-3 minutes. The excess solvent was shaken off and the coupons rinsed in acetone. The coupons were dried in the oven at 38 ± 3°C (100 ± 5°F) for 15 minutes. The coupons were removed and cooled in a desiccator. The analytical balance was calibrated as per the vendors recommendations. An inverted 150 mL glass beaker was placed on the analytical balance. The inverted beaker was used to avoid misleading balance readings associated with the magnetic affects of the metal coupons on the balance. The coupons were placed on the beaker and weighed three times to the nearest 0.1 mg.

The coupons were assembled for testing with wire, screws, and mated nuts in the same manner as the counter electrodes. The lower 1 1/2 inch portion of the coupons was taped with masking tape. The Petrolite BEE SQUARE 175 Amber Masking Wax was heated to its melting point of 80°C (175°F). The coupon was dipped into the wax until a thick wax coat built up on the coupon and the bottom 1/4 portion of the wire. Coupons were waxed to avoid galvanic coupling which could occur at the connection between the attachment wire and the coupon.

The waxed coupons were allowed to cool before the tape was removed, baring the metal surface beneath. Prior to stripper testing, a cotton swab was dipped into a beaker of tetrachloroethylene that was maintained at a temperature of 66 ± 3°C (150 ± 5°F). The bare metal portion of the waxed coupon was swabbed with tetrachloroethylene to remove residual wax, fingerprints, dust, and tape glue. The coupons were then attached to the bus bars, as previously described, and testing begun. All test coupons were run in duplicate, with two sets of silver coupons run per operating parameter tested. Silver coupons were run in duplicate at the beginning of the test week. This was a quality control measure to ensure the basis metal coupons were subjected to the same stripping conditions as the initial silver coupons.

Once testing had been completed, the coupons were scrubbed with a scouring pad, soap, and water to remove residual stripping solution and any oxide coatings. They were rinsed in distilled water, and dipped in acetone. The coupons were placed in the freezer for 3-5 minutes to harden the wax and

facilitate its removal. The wax was removed by peeling it from the coupon. The height of the bared metal portion of the coupon was measured three times from the bottom edge to the wax line. An average value was obtained and recorded, and the wire, screw, and mated nut of the coupon were disassembled. The entire coupon was scrubbed with a scouring pad, soap, and water, then rinsed in distilled water, and dipped in acetone. The coupon was immersed in a beaker of tetrachloroethylene at a temperature of 66 ± 3°C (150 ± 5°F) for 2-3 minutes, using nonmetallic tweezers as before. The coupons were rinsed in distilled water, dipped in acetone, and oven dried at 38 ± 3°C (100 ± 5°F) for 15 minutes. These were then cooled in a desiccator before weighing. The analytical balance was calibrated and each coupon weighed as before. The average weight was taken and the stripping rate calculated.

Surface characterization of basis metal coupons was based on visual inspection and microscopic examination. The microscope was used to count the number of pits within the area which appeared to have the most surface attack when visually examined. If the number of pits in this area was plentiful, "TNTC" was used to signify the area contained pits which were too numerous to count. The pit density was determined by the number of pits per surface area. Surface area was based upon the magnification of the area (200X, 400X) and converted to centimeters or inches, as required.

Four noncyanide silver strippers were selected for field-testing from Phase II (FY 89) laboratory tests. These strippers are: McGean-Rohco Inc., Rostrip 999; Technic Inc., Non-Cyanide Silver Stripper; Technic Inc., Cy-Less Electrolytic Gold Strip, and Kiesow International Co., Nickel Stripper ST. Kiesow International Co., has moved from their last known address and has left no forwarding address. Nickel Stripper ST was therefore dropped from field-testing. The three remaining silver strippers will be referred to as Rostrip 999, Technic Ag, and Cy-Less Au, respectively.

Several types of experiments and analyses were conducted to optimize operating parameters, and to determine the effects of diverting from the manufacturers operating parameters. The operating parameters included stripping rate and basis metal protection as a function of time, temperature, pH, applied current/voltage, silver loading, and stripper longevity. All

operating parameters were set according to manufacturer specifications (Appendix B) except for temperature and the variable to be tested. Three 1.2-liter volumes were prepared for each test.

Temperature tests were run at 32, 46, and 60°C (90, 115, and 140°F). This evaluated the performance of strippers at the summer ambient temperature up to the maximum temperature the plating shop would allow. The temperature was regulated by submerging the reactors in a constant temperature water bath.

Evaluation of pH was performed by operating 1 pH unit above and below the manufacturers recommended operating range as well as at the recommended optimum (or median if no optimum is specified). The pH of each solution was monitored with litmus paper, and adjusted to the pH required with 6 Molar sodium hydroxide or 6 Molar glacial acetic acid.

The effect of the applied voltage/current was determined by using the recommended operating range as specified by the vendor. Testing was done at the lower and upper limit as well as at the recommended optimum or median, if no optimum was specified. In the case where only the optimum was specified, tests were run at 20 percent above, 20 percent below, and at the optimum specified.

The effect of silver loading was determined by setting operating parameters to the manufacturers optimum settings and testing the silver-stripping rates with the solution loaded by increments of 0.5 oz/gal (3.8 g/L) silver. Testing continued until the stripping rate dropped below the acceptable level used in the plating shop.

The solutions were evaluated fresh, and after they had been allowed to sit for a few months, to determine how stripping rate was affected with age.

D. LABORATORY STRIPPING TEST EQUIPMENT AND PROCEDURES

1. Equipment

This test has been previously discussed in the Phase I Final Report (Ref. 1). Equipment needed to perform these tests include: a constant temperature bath in the range of ambient to 46°C (150°F), glass reactor vessels, condensers, submersible stir plates, volumetric glassware for solution preparation, and an efficient hood or proper ventilation.

2. Procedures

The laboratory tests for obtaining stripping rates were performed using the procedures outlined in Tables 2 and 3. They are similar to the procedures contained in the Phase I document (Ref. 1).

E. ELECTROCHEMICAL TEST EQUIPMENT AND PROCEDURES

1. Equipment

Electrochemical stripping tests were performed using a Princeton Applied Research Corporation (PARC) Model 342 Galvanostat/Potentiostat with an IBM computer interface, printer, and *SoftCorr* corrosion measurement software. Other tests (zero-current potential and reference electrode checks) were performed using a Bio-Analytical Systems (BAS) CV-27 with an X-Y plotter. A standard three-electrode cell was used for all tests (working electrode-test metal, auxiliary electrode-platinum wire, reference electrode - Ag/AgCl in saturated KCl). Chemicals were generally of reagent grade and used as received. Purified water (Nanopure system) was used for preparation of all test solutions.

2. Procedures

A PARC potentiostat/galvanostat and a Bioanalytical Systems CV-27 were used in the electrochemical tests. The following techniques were

TABLE 2. STRIPPER PERFORMANCE TESTING WITH METAL-PLATED COUPONS.

Objective: To quantify the stripping ability of plate metal strippers and assess their corrosion properties toward basis metals.

Procedure:

1. Begin heating water bath to temperature (see test plan, allow several hours to reach temperature).
2. Carefully measure and record the dimensions [height (H), width (W), thickness (T), and diameter of the hole (d = 2r)] of each coupon using calipers.
3. Calculate the surface area of each coupon using the following equation: $S.A. = 2(H \times W) + 2(W \times T) + 2(H \times T) - 2\pi r^2 + (2\pi r \times T)$. Note that the units of the surface area will be the same as the units of the measurements (most likely mm).
4. Clean the coupon using the following Procedure.
   a. Wipe the coupon with a kimwipe soaked in isopropyl alcohol.
   b. Dip the coupon in a 50/50 mixture of concentrated HCl and water for less than 30 seconds.
   c. Immediately dip coupon in deionized water and spray rinse.
   d. Dip into acetone and allow to evaporate.
   e. Put coupon into a drying oven set at 50°C (120°F) for 15 minutes.
   f. Place coupon in desiccator to cool and for extended storage.
5. Prepare solution to be tested.
6. Fill reaction vessels with solution and place into water bath.
7. Attach condensers, start the solution stirring, and hook up air hoses.
8. Wait until solution reaches correct temperature by testing with a thermometer.
9. Start a slow air purge.
10. Weigh coupons and record values.
11. Attach coupons to hooks and immerse in solution.
12. Record time immersed and allow coupons to react one hour.
13. After time has elapsed, remove reactors from bath and immediately remove coupons.
14. Rinse coupons with water and wipe off any smut which may have formed on the coupon surface.
15. Rinse coupons with acetone.
16. Dry coupons in an oven at 50°C (120°F) for 15 minutes.
17. Place coupons in a desiccator to cool.
18. Weigh coupons and record.
19. Calculate weight loss and stripping rate.

TABLE 3. CORROSION TESTING OF STRIPPING SOLUTIONS.

Objective: To determine the effect that stripping solutions have toward various iron containing basis metals.

Procedure:

1. Begin heating water bath to temperature (allow several hours to reach temperature).
2. Carefully measure and record the dimensions [height (H), width (W), thickness (T), and diameter of the hole (d = 2r)] of each coupon using calipers.
3. Calculate the surface area of each coupon using the following equation: $S.A. = 2(H \times W) + 2(W \times T) + 2(H \times T) - 2\pi r^2 + (2\pi r \times T)$. Note that the units of the surface area will be the same as the units of the measurements (most likely mm) and be consistent!
4. Clean the coupon using the following procedure.
   a. Wipe the coupon with a kimwipe soaked in isopropyl alcohol.
   b. Dip the coupon in a 50:50 mixture of concentrated HCl:water for less than 30 seconds.
   c. Immediately dip coupon in deionized water and spray rinse.
   d. Dip into acetone and allow to evaporate.
   e. Put coupon into a drying oven set at 50°C (120°F) for 15 minutes.
   f. Place coupon in desiccator to cool and for extended storage.
5. Prepare the passivated stainless steel (410ss) coupons.
   a. Prepare passivation solution by diluting 22.8 mL of HNO_3 (conc) with 90 mL of H_2O and then adding 4.55 g of $Na_2Cr_2O_7$. After the $Na_2Cr_2O_7$ is dissolved, dilute the solution to 200 mL.
   b. The passivation solution is then heated to 43-49°C (110-120°F) on a hot plate.
   c. The coupon (410 SS) is immersed in the solution for 15 to 30 minutes.
   d. Remove the coupon with non-metallic tongs and rinse thoroughly with nanopure water.
   e. Place coupon in a glass beaker and heat in an oven at 33.7 ± 3°C (100 ± 5°F) for 15 minutes.
   f. Store in a desiccator until used.
6. Prepare solution to be tested.
7. Fill reaction vessels with solution and place into water bath.
8. Attach condensers, start the solution stirring, and hook up air hoses.
9. Wait until solution reaches correct temperature by testing with a thermometer.
10. Start a slow air purge.
11. Weigh coupons and record values.
12. Prepare reaction vessels by creating an electrical contact between the two electrical leads holding the coupons in the solution.
13. Attach coupons to hooks (one 4340 and one 410ss) and immerse in solution.
14. Record time immersed and allow coupons to react for 24 hours.
15. During the 24 hour reaction time, it is important to make sure the water bath does not go dry. Major evaporation can be stopped by covering the water bath with aluminum foil.
16. After the allotted time has elapsed, remove reactors from bath and immediately remove coupons.
17. Rinse coupons with water and wipe off any smut which may have formed on the coupon surface.
18. Rinse coupons with acetone.
19. Dry coupons in an oven at 50°C (120°F) for 15 minutes.

TABLE 3. CORROSION TESTING OF STRIPPING SOLUTIONS (CONCLUDED).

20. Place coupons in a desiccator to cool.
21. Weigh coupons and record.
22. Calculate weight loss and record any visible defects on the surface of the coupons.

performed using these instruments: anodic potentiodynamic polarization, cyclic voltammetry, Tafel analyses and zero-current potential measurements. The experimental procedure for each of these techniques is summarized in Table 4. A standard 3-electrode cell was used for all analyses utilizing a Ag/AgCl in saturated KCl reference electrode and a platinum wire auxiliary electrode. The procedure for maintenance and conditioning of the reference electrode is contained in Table 5. The test material was fashioned into an electrode by forcing it into a piece of drilled Teflon® rod, then the end was polished to provide a smooth surface. This procedure for preparation of test electrodes was described previously in the Phase II Final Report (Ref. 2).

The zero-current potential tests were performed using eight different metals including common plate materials (silver, nickel, copper) and representative basis materials (fuming bronze, 9310 LAS, 410 stainless, 17-4PH stainless steel). Platinum was used in the tests as a reference and appears to give a good indication of the solution pH. Fuming bronze was tested initially; however, its use was discontinued after it became apparent that its readings were almost identical to the copper sample.

Although a large number of tests were performed using direct zero-current potential measurements, a different technique was adopted which promised to save a considerable amount of time for analysis. This technique is called anodic potentiodynamic polarization and is a technique which forces current through the electrode material to approximate the zero-current potential measurements. The benefits to this technique are its relative speed and the fact that in addition to a zero-current potential, it also provides a ballpark figure for the theoretical stripping rate which is used to determine the relative stripping efficiency of solutions. Once the solutions have been screened, then the more time-consuming Tafel analyses can be performed which

TABLE 4. ELECTROCHEMICAL TESTING OF STRIPPING SOLUTIONS.

Objective: To provide a rapid and small volume method for the analysis of a large number of potential stripper solutions for determination of their capability to strip plate metals or protect basis metals.

Procedure:

1) Prepare the solution to be analyzed (approximately 10 mL of solution per experiment are required).
2) Select the proper working electrode for the experiment to be performed (either plate or basis metal). The following two electrodes will be used in every experiment: auxiliary - platinum wire, reference - Ag/AgCl.
3) Measure the diameter of the electrode disk with calipers and then calculate the surface area according to the equation S.A. = πr^2.
4) Prepare the electrochemical instrument for analysis (BAS or PARC).
5) Check the reference electrode.
6) Input the following instrument parameters for each experimental technique listed below.
   a. Zero-current Potential measurement (E_{0c} or E_{corr}, BAS)
      i. No parameters need to be set, take readings until stabilized.
   b. Potentiodynamic Polarization Resistance parameters (PARC only)
      i. Set initial E = -600 mV vs R and final E = 1400 mV vs R. Use these values as a guideline since the potentials may need to be adjusted to obtain a complete spectrum.
      ii. Set scan rate= 2.0 mV/second (E_{0c} measurements are not sensitive to speed, however, theoretical corrosion rates and Tafel constant analyses require slower scan speeds).
      iii. Use the default settings for the conditioning, initial delay, and maximum current plot range.
      iv. Surface area (from <u>Step 3</u>, above), equivalent weight, and density of the working electrode are then entered.
      v. Use default settings for the Tafel ranges, line synchronization, and current interrupt.
   c. Tafel Plot parameters (PARC only)
      i. Set initial E = -250 mV vs E and final E = 250 mV vs E (these values may need to be changed in order to obtain a complete spectrum.
      ii. Set scan rate = 0.2 mV/second.
      iii. Set initial delay = 200 sec (this may need to be increased for better centering of the peak in the spectrum).
      iv. Use the default setting for the conditioning and maximum current plot range.
      v. Surface area (from <u>Step 3</u>, above), equivalent weight, and density of the working electrode are then entered.
      vi. Use default settings for the Tafel ranges, line synchronization, and current interrupt.
7) Clean the electrodes using a paste of fine grained alumina and water.
8) Immerse electrodes in the test solution making certain there is no electrical contact between them and attach leads from the instrument.
8) Run experiment.
9) Analyze data and plot if needed.

TABLE 5. REFERENCE ELECTRODE MAINTENANCE.

Objective: To assure that the reference electrode is providing a reproducible potential measurement. This is vitally important since all electrochemical experiments are based upon the value of the reference electrode.

1. Before using the reference electrode, visually inspect it to determine whether contamination of the KCl solution has occurred (indicated by discoloration of the solution or by the dissolution/disappearance of the excess KCl salt). If contamination is noticed or suspected, replace with fresh saturated KCl solution. Make sure excess KCl solid is present and add a small drop of $AgNO_3$ to saturate the solution with AgCl. This is also a good opportunity to polish the silver wire. After reassembly of the electrode, it will need to be reconditioned according to Section 3.
2. The value of the reference electrode needs to be checked every two weeks following this procedure.
   a. Take a cyclic voltammogram of a reference solution consisting of 0.50 M H_2SO_4 and >1 mM $FeSO_4$. The parameters to use for the cyclic voltammogram are: scan speed 250 mV/second, initial potential 0.0 V, potential limits of -0.1 V and 1.1 V, platinum disk - working electrode, platinum wire - auxiliary electrode, and Ag/AgCl reference electrode (to be checked).
   b. The $E_{1/2}$ value measured from the cyclic voltammogram should be 0.48 V. If the value is significantly different, the electrode should be reconditioned according to Section 3.
3. The electrode is conditioned by the following procedure:
   a. A solution of high conductivity is needed (the acid/iron reference solution may be used).
   b. Immerse the following electrodes into the solution and attach to the cell: reference - working electrode, platinum wire - auxiliary, platinum disk - reference.
   c. Set the potential to -1.1 V and turn on the cell.
   d. Allow current to flow for 60 seconds then turn off the cell.
   e. Set the potential to +1.3 V and turn on the cell.
   f. Allow current to flow for 60 seconds then turn off the cell.
   g. Repeat c-f at least 4 more times.
   h. Note that the silver wire should turn dark black and then lighten to a gray color as the potential is cycled. If this is not evident, longer times and higher potentials should be tried.
   i. After potential cycling is completed (make sure the last potential was positive) check the value of the electrode according to Section 2. If necessary, repeat Section 3.

provides a better estimation of the theoretical stripping rate expected for a particular solution.

The most accurate test to determine stripping efficiency is the use of Tafel analysis which provides theoretical stripping rates. These Tafel plots

have been used to screen solutions or formulations that perform well and should be further tested by standard weight loss techniques to determine an experimental stripping rate. This is a time-consuming analysis technique and is therefore best used to fine tune results obtained from the quicker Anodic Potentiodynamic Polarization tests discussed previously. The theoretical stripping rates obtained by Tafel analyses do show the same general trend as weight loss jar tests, although the numbers are not the same.

F. BIOLOGICAL TEST PROCEDURES

1. The 6-Hour Test

This test procedure is an adaptation of the same procedure used in Phase I (FY 88) biodegradability studies. Changes made in the procedure were significant enough to warrant reiteration. The procedure is designed to determine the activated sludge microbial population's constitutive ability to degrade ethylenediamine over a specified period of time representative of an average sludge contact time found at the Kelly AFB IWTP.

A 1-liter sample of Kelly AFB IWTP activated sludge was obtained from the main IWTP activated sludge basins. The sludge was packed on ice and sent to the INEL. Upon reception, the sludge was centrifuged, the liquid discarded, and a 1.0 gram portion was weighed into an aluminum dish. The remaining sludge was stored in a refrigerator at 5°C (40°F). The weighed portion of sludge was dried in a drying oven at 105°C (220°F) for 6 hours. The dry weight of the sample was obtained and the percent solids concentration was calculated using the initial wet weight, and the dry weight (see Appendix P for calculations). This number was used to calculate the amount of sludge needed in a 4-liter PVC column at a concentration of 2.5 grams solids/liter (see Appendix P for calculations). A 12.6 gram portion of the sludge was weighed and added to a 3 inch by 57 inch clear PVC column. Four liters of Environmental Protection Agency (EPA) dilution media (see Appendix P) was added and air was sparged from the bottom of the column. Nutrient feed (see Appendix P) was then added at a flow rate of 0.75 mL/minute. The activated sludge in this column was then used for the 6-hour test.

A six-column plexiglass test apparatus, with air connections, was used to determine the activated sludge's constitutive ethylenediamine degradation ability for 6 hours (representative of an average sludge contact time). Four of six test columns (500 mL capacity each) received 224 mL of EPA dilution media (see Appendix P), and either 1 mL of deionized water (DI) or 1 mL of a 25000 ppm ethylenediamine stock solution (final concentration of ethylenediamine in the test reactor is 100 ppm). Two of six test columns then received 24 mL of DI water. A 1 mL sample from each column was obtained for future gas chromatographic analysis. A 25 mL sample of the activated sludge was then placed in four of six Plexiglass® test columns, the compressed air was turned ON to each column, and a 1 mL time zero sample was removed after the contents had mixed for 1 minute. The 1 mL sample was filtered through a 0.45 μm glass fiber filter, and stored for future gas chromatographic analysis. A 1 mL sample was also collected, filtered, and stored after 6 hours had elapsed. The tests columns were composed of the following materials:

Column #1 224 mL dilution media
25 mL activated sludge
1 mL 25000 ppm ethylenediamine

Column #2 Same as column #1

Column #3 224 mL dilution media
25 mL activated sludge
1 mL DI H_2O
CONTROL TYPE I

Column #4 Same as column #3
CONTROL TYPE I

Column #5 224 mL dilution media
25 mL DI H_2O
1 mL 25000 ppm ethylenediamine
CONTROL TYPE II

Column #6 Same as column #5
CONTROL TYPE II

Two control types were used for this experiment. Control type I was activated sludge, media, and DI water. This control type was chosen to show that neither the dilution media, the activated sludge, or the DI water contained ethylenediamine. Control type II was media, water, and

ethylenediamine. This control type was chosen to show that the disappearance of ethylenediamine over time was not due to air stripping or reaction with the media. Gas chromatograph samples were taken before and after adding sludge, to show that no significant loss of ethylenediamine occurred as a result of biomass adsorption.

The concentration of ethylenediamine in each sample was determined by gas chromatography using a Perkin-Elmer model 8500 Gas Chromatograph equipped with a split/splitless injector, a flame ionization detector (FID), and an HP-1 crosslinked methyl silicone 0.53μ fused-silica capillary column. The injector temperature was 150°C (300°F), the oven temperature 150°C (300°F), and the FID temperature 260°C (500°F). The injection was splitless with a septa purge rate of 2 mL/minute, a carrier gas (He) flow rate through the column of 5 mL/minute, and a timed injector purge initiated 30 seconds after injection. The split vent purge rate was 25-40 mL/minute, and the make-up gas flow rate was 40 mL/minute. An integrator calculated the area under the sample peak. Each run time was approximately 2 minutes. A standard curve of ethylenediamine concentration vs. peak area was obtained using stock ethylenediamine solutions, and linear regression analysis was done. Each sample peak received from the experiment was compared to the standard curve and an ethylenediamine concentration was calculated.

2. Acclimation Test

This procedure is a modification of the ASTM procedure D 2667-82. The procedure is designed to determine if a microbial population is able to utilize a particular carbon source given a reasonable amount of time to do so. The term "reasonable" in this case is defined as 72 hours. This time of 72 hours was chosen because this reflects the absolute maximum amount of time the IWTP at Kelly AFB can run in the recycle mode to allow for acclimation of a sludge culture. Therefore, it was decided that if a sludge culture could not acclimate within 72 hours, the technology is not feasible to pursue using that sludge culture.

A 5 mL sample of Kelly AFB IWTP activated sludge was aseptically pipetted into a 250 mL Erlenmeyer flask containing 50 mL of sterile EPA

dilution media and 100 ppm ethylenediamine. The flask was incubated at 30°C (85°F) with shaking for 24 hours. After 24 hours a 5 mL aliquot was aseptically pipetted into another sterile 250 mL Erlenmeyer flask containing fresh media and 100 ppm ethylenediamine. This flask was incubated with shaking for another 24 hours. A third transfer was made in this manner. At the end of 72 hours, a 0.1 mL sample was removed and plated onto a sterile EPA dilution media agar plate (see Appendix P) containing 100 ppm ethylenediamine as a carbon source. The plate was incubated at 30°C (85°F) for 18 hours.

3. Isolation and Identification

This procedure is designed to physically isolate microorganisms which arise as individual colonies on an agar petri plate. The fatty acid analysis methodology is an accepted technique for bacterial identification. The microorganisms will be identified to determine if they belong to a family or genus of known enteric pathogens.

Individual colonies which arose on the ethylenediamine plate after 18-hours incubation were aseptically picked off with a sterile loop and streaked onto separate sterile EPA dilution media agar plates containing 100 ppm ethylenediamine. These plates were incubated for an another 18 hours. After incubation, each strain type was streaked onto a sterile trypticase-soy agar plate, sealed, packaged, and sent to an independent laboratory for identification via fatty acid analysis.

4. Verification of Ethylenediamine Degradation

This procedure is designed to verify that the microorganisms isolated above are able to utilize ethylenediamine as a carbon and energy source. The evidence for biodegradation will be a loss of substrate over time, an increase in media pH over time (deamination), and an increase in biomass (solution turbidity) over time.

Each strain was placed in a separate 250 mL Erlenmeyer flask containing 50 mL of sterile EPA dilution media (at pH 7) and 100 ppm ethylenediamine. A 1 mL sample was aseptically collected and the optical

density at 440 nm was determined. Sterile media containing 100 ppm ethylenediamine was used as a blank. The 1 mL sample was then filtered and stored for future gas chromatographic (GC) analysis of ethylenediamine concentration. The flasks were incubated at 30°C (85°F) with shaking for 18 hours. At the end of the incubation period a 1 mL GC sample was aseptically collected and the optical density at 440 nm was again determined. The 1 mL sample was then filtered and analyzed by gas chromatography. The final pH in each flask was obtained to determine if deamination occurred. Sterile controls were run using minimal media and ethylenediamine to show that air stripping or volatilization was not responsible for the loss of substrate over time, and that without microorganisms present the ethylenediamine did not degrade spontaneously. Other control flasks containing dilution media and microorganisms were run to show that any change in solution turbidity or pH was not due to media components and that ethylenediamine was the only carbon source available for growth.

G. COLORED WATER IDENTIFICATION

Cyanide metal-stripping solutions were prepared according to the Air Force C-106 process, as outlined in T.O. 42C2-1-7. The solution was heated to 130°F for 24 hours to generate a sufficient quantity and concentration of the colored solution to be used for subsequent testing. The solution was slowly acidified (in a hood!) to a pH less than 2 with 12 Molar hydrochloric acid to drive off all of the free cyanide. The resulting aqueous solution was then analyzed using Resonance Raman spectroscopy and was also used as a stock solution for the other identification tests.

One test using the stock solution involved extreme acidification of the solution. A small sample of the stock solution (5 mL) was added to 20 mL of concentrated hydrochloric acid. The red color did not change, however a voluminous white precipitate was formed. The precipitate was collected by filtration and washed with concentrated hydrochloric acid. The red solution was analyzed using HPLC. The precipitate was further characterized using Liquid Chromatography.

Another technique used to attempt isolation of the red component utilized standard liquid/liquid extraction techniques. This was an attempt to extract the red colored component out of the water and into an organic solvent. A number of organic solvents were tested and they included: toluene, methylene chloride, THF, hexane, and chloroform. Toluene was the only solvent which developed a slight coloration during the extraction process. The other solvents displayed no noticeable color change with extraction and were not analyzed further. The toluene solution was analyzed using GC-MS.

H. FLUID AGITATION

To characterize the flow, the tank was divided into eighteen different sections, as shown in Figure 5. Each nozzle was supplied with 35 psig and the resulting flow in each region was analyzed by recording the movement of several dozen 4mm polystyrene balls suspended in solution. Movement of the polystyrene balls could be seen through the tank wall, which helped identify flow patterns near the walls. For regions deep in the tank, away from the wall, movement of the balls could be determined by reaching down into the tank. Three solvent action test runs were performed - a 4-minute run with each manifold (either 1-, 2-, 3-legged).

Subsequently, the balls were removed and twenty wires were hung from boards arranged at various points in the tank. Hard candies were then hung at two levels, approximately 7 and 17 inches deep within the tank. The positions of the candies are shown in Figure 6. The candies were weighed before and after immersion to determine a weight loss which was used to determine relative rates of flow.

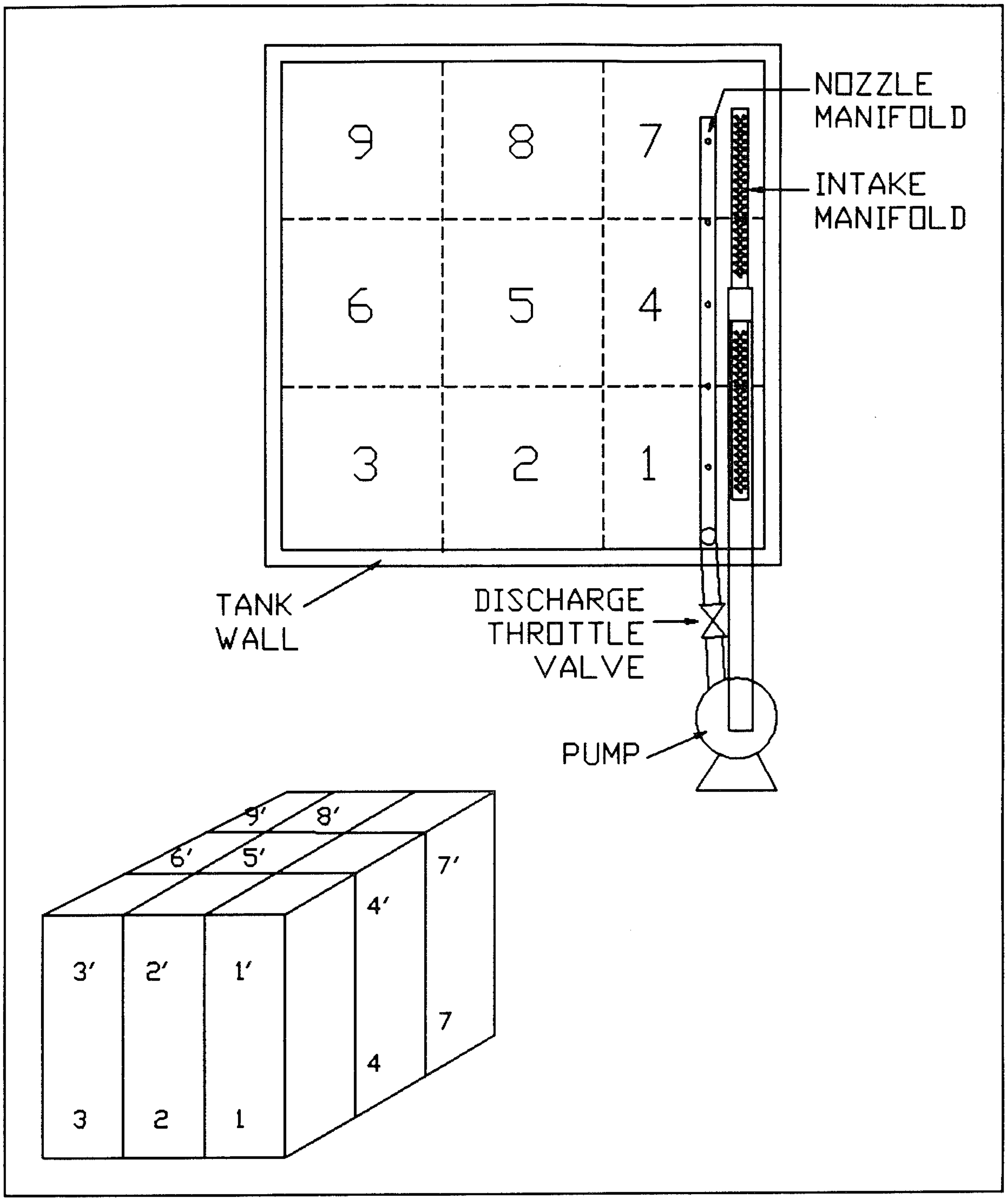

Figure 5. Fluid Agitation Test Equipment Layout.

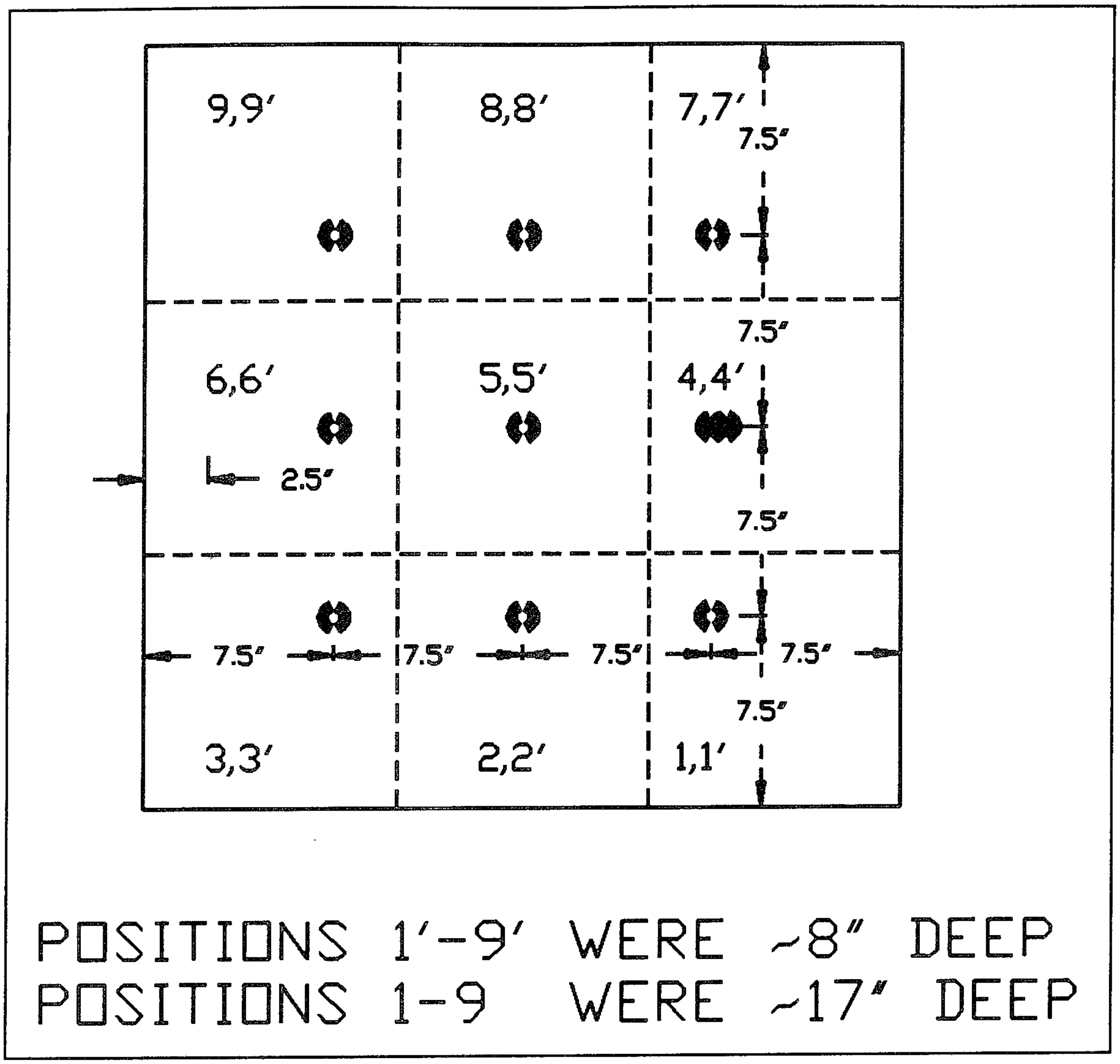

Figure 6. Fluid Agitation Test Placement of Candies.

SECTION IV
RESULTS AND DISCUSSION

Noncyanide nickel stripper implementation was realized during this phase of activity. Field-testing of three commercial noncyanide nickel strippers and three noncyanide silver strippers was completed and consequently, additional strippers to be implemented in FY 91 (Phase I of the Demonstration of Noncyanide Metal Strippers Program) were identified. Generic nickel strippers were laboratory tested, yielding some formulations that can be field-tested next year (FY 91). Additional support technologies such as the biodegradation of stripper components, fluid agitation, and colored water identification were also investigated with these results reported. The investigation and completion of these tasks contribute to the NCYS Program goal to replace cyanide solutions with noncyanide alternatives, to reduce waste, and to enhance performance of existing processes.

A. IMPLEMENTATION OF NONCYANIDE NICKEL STRIPPERS

The results to be discussed were obtained from the implementation of two noncyanide metal strippers at the Plating Shop (building 301) at SA-ALC, Kelly AFB in San Antonio, Texas. Implementation of these strippers meets the primary goal established in the Noncyanide Strippers To Replace Cyanide Strippers Program contract, as outlined in the Phase I and II Final Reports (Refs. 1,2).

1. Implementation of CLEPO 204 (Frederick Gumm Chemical Co., Inc.)

One of the two noncyanide metal strippers implemented was CLEPO 204, manufactured by Frederick Gumm Chemical Company. Implementation was initiated in the plating shop on August 15, 1990, based upon the field optimization test results from Phase II. This stripper met the requirements established by the Kelly AFB plating shop management including excellent basis metals protection, a good stripping rate for electrolytic nickel, excellent rinsing properties, and other exceptional service properties.

During the implementation period from August 15th to October 30th, 1990, approximately 300 aircraft engine parts were evaluated. These represented a cross section of parts from three different aircraft engines which were currently being processed at the plating shop. A list of these parts is given in Table 6. The stripper line chemist approved this stripper for full production usage for a full three shifts after observing the excellent results obtained during the first 2 weeks of implementation.

The product bulletin for CLEPO 204 does not specify any chemical control analyses, therefore, a pH range control of 10.0-11.0, as recommended by field-test data, was specified for use. During the first 2 weeks, the pH of the stripping solution was measured daily and remained fairly constant. After the second week the pH was measured only once a week. Periodic tests for plate metal stripping and basis metal protection were performed. The

TABLE 6. AIRCRAFT PARTS USED FOR IMPLEMENTATION TESTING OF CLEPO 204.

F-100 Engine Parts		
Bearing Scoops	- 43	each
Shafts	- 27	"
Sun Gears	- 11	"
T-56 Engine Parts:		
Compressor Cases	- 39	each
Tie Bolts, short	- 36	"
Tie Bolts, long	- 8	"
Lock Prop. T Brg.	- 10	"
Lock Prop. T Nuts	- 29	"
B-52 Engine Parts:		
Links	- 60	each
Cones	- 15	"
Lock Pins	- 10	"
Supports	- 8	"
Brackets	- 5	"

high initial stripping rate for electrolytic nickel (2.5 milliinch per hour) was the basis for the chemist's decision to use CLEPO 204 in full production.

The basis metal protection and nickel-stripping rates for all aircraft engine parts correlated well with the coupon test results, which showed that only C4340 and D6AC showed any sign of corrosion after 24 hours of immersion. This was evidenced by the development of minor surface stains which could be removed by cleaning. There was no visual evidence of pitting on the surface of the coupons, so the results may be due to the extended immersion time (24 hours).

Most of the aircraft engine parts were completely stripped in 4 to 8 hours. The exceptions were parts that have a large thickness of plate metal that permits machining operations to finish the parts. All stripped aircraft engine parts were found to be free of corrosion effects such as etching and pitting. In stripping the T-56 Engine Compressor cases, a coating residue was present after rinsing because this part is coated with a metallized nickel thermal barrier coating and not a nickel plate. All these compressor cases required one 6-hour immersion to achieve the stripping process; however, because of the thick metallized coating, the compressor case also required the normal aluminum oxide blasting operation to completely remove the coating.

No solution odor or emission problems were encountered during the evaluation period. The present push/pull ventilation system contained the solution vapors during production, therefore, excessive vaporization was not a problem with CLEPO 204. This stripper was not tested for regeneration since the stripping rate was still satisfactory (greater than 1 milliinch per hour) at the end of the implementation test period (2.5 months).

Based on the implementation results, CLEPO 204 nickel stripper can be used in lieu of the cyanide based nickel stripper (C-106) in applications that require the stripping of electrolytic nickel plates from either low or high alloy steel basis metal parts in the temperature range of 52-57°C (125-135°F). The benefits that the Air Force will realize by using CLEPO 204 are improved

worker safety, reduced waste generation (based on stripper stability), and better production rates for the stripping process.

2. Implementation of the Nickel-Sol Process (Electrochemicals)

The Nickel-Sol Process Stripper was implemented at the SA-ALC plating shop on July 16, 1990, as a replacement for the 50 percent (volume) nitric acid stripper. Nickel-Sol was evaluated for stripping rate, basis metal protection, regeneration and vapor emission properties in a production environment. During the evaluation period from July 16th to September 28th, 1990, a total of 944 parts currently stripped in nitric acid were evaluated. These parts are listed in Table 7.

The results for the implementation of the Nickel-Sol process determined that only stainless steel basis metal parts could be used. Of the approximately 900 stripped F-100 engine variable vanes, 90 percent were stripped within 4 hours and the remaining 10 percent required an additional

TABLE 7. AIRCRAFT PARTS USED FOR IMPLEMENTATION TESTING OF NICKEL-SOL.

F-100 Engine Parts	
Variable Vanes:	
4th stage	- 248 each
5th stage	- 326 "
Inlet guide	- 340 "
Sync Rings:	
4th stage	- 7 each
5th stage	- 8 "
Inlet guide	- 4 "
Combustion Chambers:	
I.D. - 2 each	
O.D. - 2 "	
GT Engine Parts:	
Nozzle Assembly	- 2 each
Scoops	- 5 "

2 to 4 hours for stripping. All the F-100 engine Sync. Rings were completely stripped within 4 hours. The F-100 engine combustion chambers, which have a metallized nickel base coating, required the 4-hour immersion plus a standard aluminum oxide blasting operation to remove the coatings. The Gas Turbine (GT) engine parts required three cycles (a four hour immersion followed by a blasting operation) to completely remove the coatings. This is not unusual since these parts presently require up to eight such cycles.

Regeneration of the stripping solution restores the electroless nickel-stripping rate from 0.6 to 3.4 milliinch per hour. The electrolytic nickel-stripping rate was determined to be 8.3 milliinch per hour after regeneration. Since the major application for this stripper involves the stripping of electroless nickel (Ni-P) coatings, the electrolytic nickel-stripping rate was measured only once. No odor/vapor problems occurred during the implementation. The present push/pull ventilation system proved adequate for production use of this stripper.

The results from the 24-hour basis metal corrosion field-tests correlated well with the results obtained using aircraft parts. Two exceptions were 410 stainless steel and titanium metal which showed corrosion effects during the field-tests. These basis metals showed a slight mass change and a visible color change on the surface of the coupons. The titanium coupon changed from a metallic gray to a golden tan color and the 410 stainless steel coupon partially changed from a shining metallic color to a matte gray. These basis metal problems were sporadic and occurred in only half of the field-tests performed. Attack upon these two basis metals may be explained by the longer immersion period (24 hours) used on the test coupons since basis metal protection for all the stripped aircraft engine parts was excellent (i.e., no corrosion was observed on any of the parts).

Basis metal protection of the stainless steel and titanium parts was found to meet the plating shop criteria when the maximum exposure time was eight hours. To determine if Nickel-Sol exhibited any intergranular attack on Inconel-X750, metallurgical analyses were performed by the SA-ALC Metallurgical Laboratory on F-100 engine 5th-stage variable-vane sections. A total of four parts were tested with two exposed to Nickel-Sol for 4 hours and

two exposed for 8 hours. The results obtained by the Metallurgical Laboratory found no defects on the I-X750 basis metal parts. Since stripping of nickel from titanium vanes is another required application for this implemented stripper, it was decided by Ray Martinez (EG&G Idaho, Inc.) and Kurt Greebon (Kelly AFB) to have additional metallurgical analyses performed on this basis metal. Results obtained by the SA-ALC MAQCM Metallurgical Laboratory on titanium parts (F-100 engine inlet guide vane sections) under similar test conditions also showed no deleterious effects from exposure to the solution, as evidenced by the attached MAQCM report results (Appendix R). An unusual effect of using this stripper was the formation of a wet film on some of these titanium parts. A ten-minute cold rinse followed by a five-minute hot rinse should be sufficient to prevent this from occurring. Because of the operating volume limitation (380 liters, 100 gallons), the F-100 augmenter liners could not be tested. However, laboratory evaluation of a sample of this liner coating found that Nickel-Sol was comparable to the presently used Nitric Acid stripper in removing this material.

Evaluation of these results suggest that Nickel-Sol can be used in lieu of the presently used 50 percent (volume) Nitric Acid stripper. The benefits that can be realized by the Air Force with the use of this stripper are increased worker safety (through elimination of NO_x fumes) and reduction of chemical waste since the Nickel-sol stripper can be regenerated almost indefinitely. Implementation of Nickel-Sol could eliminate 23,000 liters (6000 gallons) of heavy metals/nitric acid waste per year.

B. FIELD-TESTING OF NICKEL STRIPPERS

Only the nickel strippers tested during this year are included in the following discussion. This was done to prevent a repetition of information that can be found in the Phase II Final Report (Ref. 2). Each product's test results will be individually discussed with relative comparison and effectiveness judgements reserved for the Conclusions and Recommendations Sections of this report. All solutions demonstrated compatibility with the masking material used at Kelly AFB. Graphs showing the effects of temperature, pH, nickel loading and regeneration are depicted in Appendix L.

1. B-9 Nickel Stripper (MetalX, Inc.)

B-9 Nickel stripper is an aqueous, alkaline, amino acid-based stripper designed to remove both electrolytic and electroless nickel deposits from steel by immersion. The use of amino acids makes this stripper very easy to biodegrade. The other components, sodium carbonate and sodium *m*-nitrobenzenesulfonate, are both potentially biodegradable and not considered hazardous. This stripper is similar in composition and performance to Ni-plex 100 which is discussed next. The field-test data are presented in Appendix E.

Solutions were prepared according to the manufacturers' product bulletin (Appendix B) and analyzed for the following conditions. The temperature was tested at 50, 60, 65°C (120, 140, and 150°F) while the pH was varied from 9.6 to 10.6 during the field-tests. A narrower pH range was tested for B-9 at the suggestion of the developer and Ray Martinez. The solution was tested with nickel loadings of 0.95 and 1.58 oz/gal (7.1 to 11.8 g/L). The loaded solution was then regenerated twice according to the manufacturer's specifications with the stripping and corrosion rates remeasured for each regeneration.

Plate metals are, in general, stripped better at higher temperatures for B-9. The stripping rate for electrolytic nickel doubled from 0.7 to 1.4 milliinches per hour in going from 50 to 65°C (120 to 150°F). The results with electroless nickel are excellent, starting at around 0.5 and ending at about 0.8 milliinch per hour. The analogous stripping rates for both types of nickel coatings is unusual and compared to other strippers we have tested, the rate for electroless nickel plates is excellent (only surpassed by Nickel-Sol). Unfortunately, the stripping rate for electrolytic nickel deposits is only mediocre at best, the 1.4 milliinches per hour is surpassed by a number of other strippers. The basis metal protection is unusual in that it shows a slight increase in corrosion from 50 to 60°C (120 to 140°F) and actually decreases at the highest temperature 65°C (150°F).

The manufacturer recommends a very narrow pH range for operation of B-9 (between 9.2 and 9.8) and from our tests, this pH range appears to be the optimum for stripping both types of nickel deposits. As the pH increases,

basis metal corrosion is reduced, however, the plate metal-stripping rate is also significantly reduced. Therefore, the pH range recommended by the manufacturer (9.2-9.8) should be maintained.

The major drawback to the use of this stripper (and for most strippers) is the fall-off of stripping efficiency which occurs upon loading the solution with nickel. With nickel loading approaching 1.5 ounces of nickel per gallon of solution (11.2 g/L), the stripping rate falls to negligible values (less than 0.1 milliinch per hour). Fortunately, the solution can be regenerated to restore the stripping rates to acceptable values (Ni-S about 1 milliinch per hour, Ni-P about 0.5 milliinch per hour). The regeneration of the solution appears to cause a slight increase in the corrosion of the basis metals (although the rate is still in the acceptable range), but dramatically restores the stripping efficiency of the solution toward nickel plates.

2. Ni-plex 100 (M&T Harshaw)

Ni-plex 100 is an aqueous, alkaline stripper consisting of sodium carbonate and other nonhazardous organic chemicals (amino acids). It is recommended for immersion stripping of both electroless and electrolytic nickel deposits (Ni-P and Ni-S) from steel. Data obtained during the field-tests are compiled in Appendix F. As previously mentioned, this formulation is very similar to MetalX B-9.

Solutions were prepared according to the manufacturers product bulletin (Appendix B) and anaylzed under the following conditions. The temperature was tested at 50, 60, 65°C (120, 140, and 150°F) while the pH was varied from 9.7 to 11.2 during the optimization process. The solution was tested with nickel loadings of 1.0 and 2.0 oz/gal (7.5 and 15.0 g/L). The loaded solutions were then regenerated according to manufacturers specifications and the stripping and corrosion rates remeasured.

The temperature tests show that 60°C (140°F) was the optimum temperature since both the plate metal-stripping rates and basis metal protection were optimal at that temperature. The stripping rate for

electrolytic nickel increased from 0.7 to about 1.2 milliinch per hour by increasing the temperature from 50 to 60°C (120 to 140°F) while electroless nickel increased from 0.3 to about 0.8 milliinch per hour over the same temperature range. Increasing the temperature from 60 to 65°C (140 to 150°F) caused only a slight decrease in the stripping rates (0.1 milliinch per hour) for both nickel plates. Copper did not strip well, but was not low enough to guarantee basis metal protection. The ferrous basis metals were all protected, showing very minute weight losses.

The graph of the pH profile (Appendix L) shows that the optimal nickel-stripping occurred at pH 10.0. The stripping rates for both plate metals vary only slightly over the range tested (pH 9.7 to 11.2) with changes in stripping rates of only 0.2-0.3 milliinch per hour. The electrolytic nickel-stripping rates vary from slightly less than 1 to about 1.2 milliinches per hour over the full pH range. The electroless nickel-stripping rate increased rapidly from pH 9.7 to 10 jumping from about 0.4 to about 0.8 milliinch per hour. When the pH was increased further, the stripping rate for electroless nickel remained constant. Surprisingly, the basis metals have a greater pH effect and exhibit greater protection at the lower pH (9.7). From this information, we would recommend that the stripper be maintained as close to pH 10 as possible.

The loading of the stripping solution with 1.0 ounce per gallon (7.5 g/L) of nickel resulted in only slightly decreased stripping rates for both plate metals. The addition of more nickel to 2.0 ounces per gallon (15 g/L) shut down nickel-stripping to around 0.1 milliinch per hour. The loaded solution did regenerate to an increased stripping rate, however both nickel-stripping rates were below acceptable limits (less than 0.5 milliinch per hour for Ni-S and 0.2 milliinch per hour for Ni-P). The basis metal protection was excellent over all loading limits and after regeneration.

3. Enstrip N-190 (Enthone Inc.)

Enstrip N-190 is an aqueous, alkaline, organic amine (ethylene-diamine) based stripper which is designed to strip electroplated nickel deposits (Ni-S) from steel, copper, and copper alloys by immersion. The main

ingredient (ethylenediamine) is the same as in the formulation CLEPO 204 which Enstrip N-190 strongly resembles. The results from these field-tests are presented in Appendix G.

Solutions were prepared according to the manufacturers' product bulletin (Appendix B) and the following conditions investigated. The temperature was tested at 50, 55, 65°C (120, 130, and 150°F) while the pH was varied from 10.8 to 12.3 during the optimization process. The solution was tested with nickel loading of 0.5, 1.0, and 1.5 ounces per gallon (3.8, 7.5, and 11 g/L).

A plot of the effect of temperature on stripping rate is shown in Appendix L. This indicates that 55°C (130°F) is the best temperature for stripping electrolytic nickel, while for electroless nickel the highest temperature yielded the best stripping rate. Basis metal protection is better at lower temperatures; in most cases, an increase in corrosion of 5- to 10-fold is observed with the increase from 50 to 65°C (120 to 150°F).

Stripping and corrosion rate plots for various pHs show that 12.28 is best for basis metal protection, and that stripping of Ni-S is also excellent at this pH. The stripping of electroless nickel deposits is negligible (<0.25 milliinch per hour) at all pH units tested. Electrolytic nickel reaches a minimum stripping rate at pH 11.5, but increases at both the lower and higher pHs tested.

Loading tests show that the stripping rate of electrolytic nickel drops significantly upon small additions of nickel. The stripping rate drops from greater than 1.5 to less than 0.5 milliinch per hour upon addition of only 0.5 ounce of nickel per gallon of solution (3.8 g/L). Incredibly, the addition of more nickel (to 1.5 ounces per gallon, 11 g/L) seems to reactivate the solution and the stripping rate for electrolytic nickel is restored to 1 milliinch per hour.

C. FIELD-TESTING OF SILVER STRIPPERS

The data obtained throughout the field-testing of the three noncyanide silver strippers and the Air Force's Electrolytic Cyanide Process (C-101) can be found in Appendices H-K. This consists of field-test data for optimization of temperature, pH and current density for the three commercial noncyanide silver-stripping formulations as well as the results from standard operating conditions for the Air Force's Electrolytic Cyanide Process (C-101). The stripping and corrosion rates from the optimization studies are graphed in Appendix M, while the performance of the three strippers is compared in the Conclusions and Recommendations Sections of this report.

1. Rostrip Electrolytic Stripper 999-SP (McGean-Rohco, Inc.)

According to the manufacturer, this electrolytic stripper is formulated to remove nickel, copper, chromium and other plate metals from steel parts. It is composed of a mixture of sodium nitrate, sodium nitrite, and alkaline pH controlling agents. The excellent performance for stripping silver during laboratory testing in Phase II (FY 89) intimated further field-testing be done during Phase III (FY 90).

Exemplary silver-stripping rates (from 6 to 16 millinches per hour) were observed which surpassed the other two noncyanide silver strippers tested and the cyanide C-101 silver-stripping process in use at the Kelly AFB plating shop. Basis metal protection was comparable to that seen in the plating shop, with two exceptions - both Haynes 188 and Inconel 718 underwent heavy corrosion in Rostrip 999-SP. The C-101 process afforded excellent basis metal protection for all basis metals tested, including Haynes 188 and Inconel 718.

Two operating temperatures were tested, 32 and 46°C (90 and 115°F). Temperatures higher than 46°C (115°F) were not tested since the manufacturer stated that pitting of basis metals would occur if temperatures exceeded 40°C (104°F). This was verified when pitting of basis metals was observed at 46°C (115°F). The best performing temperature for this stripper was 32°C (90°F).

The pH of this stripper was tested at 8, 11, 12, and 14. The pH jumps greater than 1 unit were performed when the stripper showed little change between pH 11 and 12. Also, the pH of 8 was verbally recommended by the manufacturer for enhanced nickel-stripping ability. This pH also provided the highest silver-stripping rates of all the pH values tested. Unfortunately basis metal protection was sacrificed at this pH. The best combined silver-stripping rate and basis metal protection occurred in the pH range of 11-12.

The calculated amperages used for the current density optimization tests were 3.8, 4.8, and 5.8 amperes. The test results show that there is a parallel increase in stripping and corrosion rates. When the current density was increased (as seen in the 5.8 ampere tests), silver-stripping rates increased as did the basis metal corrosion rates. When the current density was decreased (3.8 ampere tests), basis metal corrosion decreased, but so did the rate of silver-stripping. The median current density (4.8 amperes) provided the best combined silver-stripping rate and basis metal protection.

Loading tests for this silver stripper are currently underway. Rostrip 999-SP is easy to use and poses no maintenance problems. It appears to be self cleaning and precipitates any metals (which may have dissolved in the solution during the stripping process) as a solid sludge. The solution merely needs to be decanted periodically to avoid excessive build up of this sludge.

2. Non-Cyanide Silver Stripper - Electrolytic (Technic Inc.)

This noncyanide silver stripper is specifically designed to electrolytically strip silver from various basis metals. It is composed of potassium hydroxide and a derivative of succinic acid.

Technic Ag Stripper exhibited an average silver-stripping rate of 2 milliinch per hour, the lowest silver-stripping rate of the three commercial noncyanide silver strippers tested, and even lower than the C-101 process. Technic Ag provided the best basis metal protection of the three strippers tested, although corrosion of Haynes 188 and Inconel 718 was still observed.

Three temperatures were tested: 32, 46, and 60°C (90, 115, and 140°F). The silver-stripping rate was low (1 milliinch per hour) as were basis metal corrosion rates. There was essentially no change in stripping or corrosion rates with change in temperature.

Three different pHs were tested - 9, 10, and 12. A pH of 10 was recommended by the manufacturer, and provided the best combination of silver-stripping rate and basis metal protection. The pH of 12 increased the silver-stripping rate slightly (about 1 milliinch per hour), however, two basis metals (Haynes 188 and Inconel 718) also underwent increased corrosion rates at this pH.

The voltages recommended by the manufacturer were between three and six. Tests conducted at 3.0, 4.5, and 6.0 volts showed essentially no change in silver-stripping rates and basis metal protection. Therefore the median voltage (4.5) was adequate (assuming equivalent economics).

Technic Ag stripper is easy to use and poses no maintenance problems. However, low silver-stripping rates were consistently observed with this stripper (average rate of 2 milliinch per hour). Consequently, it was eliminated from further loading tests and basis metal protection tests.

3. Cy-Less Electrolytic Gold Strip (Technic Inc.)

Cy-Less Electrolytic Gold Strip was formulated to electrolytically strip gold. It is an acidic solution containing thiourea (a suspected carcinogen). This stripper was tested as an electrolytic silver stripper in Phase II and performed well, therefore, it was targeted for field-testing during Phase III.

Cy-Less Gold Strip was tested at the following temperatures: 32, 46, and 60°C (90, 115, and 140°F). The silver-stripping rate was invariant over the temperature range tested. Basis metal protection was best provided at 32°C, which is below the operating temperature recommended by the manufacturer. This temperature yielded the best silver-stripping rate and basis metal protection, and at the easiest temperature to maintain.

The pH range tested included the following pHs: 3.0, 4.5, and 6.0. While the silver-stripping rate showed little change over the pH range tested, basis metal protection was sacrificed at pH 3.0 and 6.0. At pH 3.0, Haynes 188 and Inconel 718 exhibited significant corrosion rates. Haynes 188 continued to increase its rate of corrosion at pH 4.5 and 6.0, whereas the corrosion rate for Inconel 718 decreased at these pHs. Although Haynes 188 was significantly attacked at every pH tested, the best combination of silver-stripping rate and overall basis metal protection was at the manufacturer's recommended pH of 4.5.

The following amperages, calculated from the current density recommended by the manufacturer, were tested: 1.0, 2.4 and 3.8 amperes. The median current density recommended by the manufacturer provided the best combination of silver-stripping rate (8 milliinch per hour) and basis metal protection.

Cy-Less Electrolytic Gold strip has some undesirable service and maintenance considerations. This stripper contains thiourea, a suspected carcinogen, and also has a tendency to coat the basis metal coupons with a black tar-like residue which must be scraped off. Because of these two drawbacks and Rostrip 999-SP's superior silver-stripping rate, silver loading tests were not pursued and basis metal tests utilizing the high-current density were discontinued.

D. LABORATORY ELECTROCHEMICAL TESTS

Of the myriad chemicals tested, no one ingredient is sufficient to produce a suitable stripping solution (the one exception may be concentrated nitric acid which will passivate ferrous alloys while concentrated, but will completely degrade the same materials upon dilution). The tests so far conducted indicate that the best stripping solution for the removal of electrolytic nickel deposits from ferrous alloys incorporates ethylenediamine as the main ingredient. The amine group appears to be a very good functional unit for the stripping and transport of nickel metal away from the surface of the nickel plated part. Ethylenediamine has an obvious advantage over ammonia

by possessing a reduced vapor pressure. In addition, ethylenediamine has been shown to be an effective corrosion inhibitor for ferrous alloys (Ref. 28).

The best solution for removal of electrolytic nickel as determined from jar tests was a formulation of ethylenediamine, nitric acid, sodium nitrate, sodium *m*-nitrobenzenesulfonate, and a small quantity of ammonium thiocyanate (Solution #24, Appendix N). Thiocyanate appears to function as a strong activator of the nickel surface and will strip nickel all by itself. However, the stripping ability of thiocyanate does not stop at nickel, since the ferrous basis metals also underwent extensive attack during 24-hour testing. Other activators were tested by addition to the basic formulation of ethylenediamine, nitric acid, sodium nitrate and sodium *m*-nitrobenzenesulfonate. Of these, thiosulfate was ineffective while thiourea proved useful at activation of nickel plates while maintaining protection of the ferrous substrates. Unfortunately, thiourea required a substantial concentration (1 Molar) before becoming an effective activator for the nickel surface. Although thiourea is biodegradable, it is a suspected carcinogen and as such would be under strict regulations. The use of thiocyanate accomplished the same activation at a lower concentration (0.05 Molar) and is relatively non-toxic and unregulated. Thiocyanate (SCN), although appearing similar to cyanide (CN), is chemically very different (i.e., several orders of magnitude less toxic and fully biodegradable).

The results of testing by the zero-current potential technique are tabulated in Appendix O. The values obtained from this type of test are similar to the values presented in tables of standard electrode potentials (Ref. 29) as would be expected. Where this technique offers its best utility is in analysis of alloys (9310, 410ss, bronze) or mixtures of chemicals of which cannot be found in any table. The data from zero-current potential measurements contained in Appendix O can be interpreted by looking for highly negative values as these denote stripping activity (either corrosion, activation, or oxidation) at the metal surface.

From analysis of the zero-current potential data contained in Appendix O, the three most effective solutions for activation of nickel were ethylenediamine (21), ammonium thiocyanate with sodium hydroxide (18), and a

mixture of glycine and sodium hydroxide at pH 8.50 (33). Likewise, the best corrosive environments observed for silver were sodium thiosulfate (2) and sodium iodide with or without hydrogen peroxide added (11-13). The values for silver are considerably less negative than those for nickel, as expected, since silver is a much less reactive metal. The results for copper have shown that just about any basic pH solution is corrosive with the best results observed in basic solutions of sodium thiosulfate (2) and ammonium thiocyanate (28).

The results of the anodic potentiodynamic polarization tests have shown that a number of solutions show a more negative zero-current potential than CLEPO 204 - a formulation which performs well for stripping electrolytic nickel and was arbitrarily chosen for reference. Most of these solutions contained ethylenediamine (which was the bath constituent receiving the most attention this year). Other effective stripper components included glycine and ammonium thiocyanate. The problem with any zero-current potential measurement is the fact that this technique is very susceptible to the influence of oxidizing or reducing reagents. Therefore, solutions containing reducing agents may falsely appear to strongly activate the material being tested and this is contrary to what should be observed in a stripping reaction. The presence of oxidizing agents would show the reverse effect and these agents would be expected to have a positive effect in stripping formulations. This requires that most results need careful interpretation, especially those containing oxidizing agents or sulfur-containing activators (thiosulfate, thiocyanate) since the sulfur tends to function as a weak reducing agent and may perturb the zero-current potential measurements.

The results of the Tafel tests have shown that, to date, formulations containing ethylenediamine are best at stripping electrolytic nickel plates and that ammonium thiocyanate, either in bulk or as a small quantity activator, also works well. This was also indicated by the zero-current potential measurements. These stripping solutions were tested by weight loss methods using plated coupons as described in References 1, 2, and 30. The electrolytic nickel plates were easily stripped, as expected, with the best solution providing a stripping rate of 2.5 milliinches per hour. This solution (24) contained: ethylenediamine (3.7 Molar), nitric acid (1.0

Molar), sodium nitrate (0.60 Molar), sodium *m*-nitrobenzenesulfonate (0.67 Molar), and ammonium thiocyanate (0.05 Molar). The only suitable solution for stripping electroless nickel (21) was also highly corrosive to the basis metals and did not pass our 24-hour immersion test.

Unfortunately, we could not pursue corrosion testing of the enhanced ethylenediamine formulation mentioned above, but the electrochemical results from Tafel plots indicate that there should be adequate to excellent protection of low-alloy steels. The best solution that was tested for basis metal protection was the exact same formula minus the thiocyanate activator (1). It showed absolutely no effect on low alloy steel (C4340) after 24-hours immersion by both weight loss and visual inspection. It is interesting to note that the stripping rate for electrolytic nickel was doubled by simple addition of a small quantity of ammonium thiocyanate (Solution 1 vs 24).

Another interesting observation from the jar tests involves the stripping rate of solutions containing thiocyanate and sodium *m*-nitrobenzenesulfonate as active ingredients. Solution 10, which contains only ammonium thiocyanate and sodium hydroxide, showed a pitiful stripping rate for electrolytic nickel (0.013 milliinch per hour). This low level of activity was not improved by addition of ethylenediamine (13). However, addition of ammonium nitrate and sodium *m*-nitrobenzenesulfonate resulted in a 100-fold increase in stripping rate, which appears dependent upon the concentration of sodium *m*-nitrobenzene-sulfonate (14 and 21). Sodium *m*-nitrobenzenesulfonate is marketed as a corrosion inhibitor for ferrous substrates, but it appears to have a dual purpose in nickel-stripping baths serving both as an activator for the removal of the nickel plate and as an inhibitor for basis metal corrosion.

E. METAL CLEANING SOLUTIONS

At the onset of Phase III testing, Tinker Air Force Base led the other ALCs in its use of the cyanide cleaner C-204 by maintaining nine 2,600- to 3400-liter tanks (700- to 900-gallon), with no forecasted reduction in use. The remaining ALCs also used this cleaner, although to a lesser extent. The experimental plans were written for this task, and the replacement cleaners

scheduled for testing were procured. They included Enthone's Endox Q 576, and alternate Air Force cleaners C-201 and C-203. The chemicals for each were procured, with testing scheduled to begin mid-May of 1990. During the first week in May, it was discovered during a conversation with Tinker personnel that Tinker AFB had already replaced seven of its nine cyanide cleaning tanks with Endox Q 576, a cleaner that had been identified for Phase III studies. The remaining two tanks of cyanide cleaner will soon be replaced as well. The status of the C-204 cyanide metal cleaner at all of the ALCs is summarized in Table 8. Since the replacement of cyanide cleaners was proceeding without our intervention, this task was eliminated.

TABLE 8. CYANIDE CLEANING SOLUTION USAGE BY ALC.

ALC	Original Tanks with Cyanide solution	Tanks Replaced with Noncyanide alternatives
Tinker	9 @ 2600-3400 liters (700-900 gallon)	7 with Endox Q 576
Kelly	1 @ 2600 liters (700 gallon)	None
Hill	None	None
McClellan	1 @ 1200 liters (330 gallon)	None
Warner-Robbins	None	None

F. BIOLOGICAL LABORATORY TESTS

1. The 6-Hour Test

The results of the 6-hour test are found in Table 9. The results demonstrate that Kelly AFB IWTP activated sludge did not manifest the constitutive ability to significantly degrade ethylenediamine under conditions defined by the experiment. Control Type I results show that no

ethylenediamine is added to the reactors from the activated sludge, the media, or the DI water. Control type II results show that no loss of ethylenediamine resulted through air stripping or reaction with media components. The results also demonstrate that no significant loss of ethylenediamine could be detected as a result of ethylenediamine adsorption onto the biomass.

TABLE 9. 6-HOUR TEST RESULTS.

The concentration of ethylenediamine is in ppm.

Column #	$[EN]_i$	$[EN]_0$	$[EN]_6$	Change in [EN]/time
1	113.2*	93.4	92.3	-1.1
2	113.8*	91.7	92.3	+0.6
3	0	0	0	0
4	0	0	0	0
5	110.2*	92.7	91.4	-1.2
6	112.4*	92.6	92.0	-0.5

LEGEND

$[EN]_i$ = initial reading before additions of sludge or DI water. These readings are higher* because they have not been diluted.

$[EN]_{0\ \&\ 6}$ = ethylenediamine concentrations at times 0 & 6 hours.

Control Type I = columns #3 and #4.

Control Type II = columns #5 and #6.

The fact that no significant loss of ethylenediamine over a 6-hour test period could be demonstrated does not mean that the organic compound itself is not biodegradable. Results from this procedure have often been misstated or misinterpreted to mean that the organic compound is not degradable, an incorrect assumption. The results of this procedure demonstrate that the current microbial population did not utilize this compound as a food source. The results in no way reflect the overall biodegradability of this organic compound.

It should be noted that the microbial population used to conduct the experiments has changed significantly since its initial collection from the IWTP. Since the amount of carbon available in the activated sludge basins is low to begin with, when the sludge sample is collected and shipped, at least a 24- to 48-hour period passes prior to reconstitution. When the sludge is received, the microorganisms are reconstituted, or revived, with a nutrient feed solution containing either phenol or glucose as a carbon source. This may or may not have been the carbon source the microorganisms were adapted to at the time of collection. It is observed that the sludge undergoes a long-lag phase (12 hours) with an initial reduction in biomass before an activated sludge population can be established in the 3 inches by 57 inches PVC reactor. It is believed that the microorganism population undergoes a significant enough change so as not to correctly represent the current population existing at the IWTP. This may result in a false negative experimental result.

The dilution media used in the test does not adequately represent the matrix found in actual Kelly AFB IWTP process water. A true test of the constitutive biodegradability of ethylenediamine by Kelly AFB IWTP activated sludge must include the process water matrix which exists at the IWTP, as well as a true representation of the microbial population. Even if it was found that ethylenediamine was degraded, using this experimental design, the results would need to be validated by further laboratory studies using conditions which more closely mimic actual field conditions (i.e., continuous-flow bioreactor experiments).

2. Acclimation Test

At the end of the acclimation period colonies were observed to be growing on agar plates prepared with ethylenediamine as the carbon and energy source.

3. Isolation and Identification

Three different strains of microorganisms were isolated. The microorganisms were positively identified by an independent laboratory (Microbial Identification Systems Inc.) which used the fatty acid analysis

method. The strains were identified as *Aureobacterium saperdae* strain KAFB#1, *Stomatococcus mucilaginosus* strain KAFB#2, and *Micrococcus luteus* strain KAFB#3. These microorganisms are Gram negative aerobic rods or cocci and are not known to be enteric pathogens.

4. Verification of Ethylenediamine Degradation

The results of this experiment are shown in Table 10. The results indicate that all three microorganism isolates degrade ethylenediamine and cause an increase in the solution pH. The optical density measurements for each flask showed that an increase in biomass also resulted. This shows that the microorganisms collected at the Kelly AFB IWTP can be induced to utilize ethylenediamine as their primary carbon and energy source. This is a promising sign because it shows that the technology has a chance of being feasible to pursue with this sludge culture. However, we acknowledge that the microbial population changes at the IWTP.

TABLE 10. VERIFICATION OF ETHYLENEDIAMINE DEGRADATION.

The concentration of ethylenediamine is in ppm.

Strain	$[EN]_i$	$[EN]_{18}$	Change in [EN]	pH_i	pH_{18}	$O.D._i$	$O.D._{18}$
KAFB#1	105.2	<1	>99%	7	10	0.00	0.82
KAFB#2	101.1	<1	>99%	7	10	0.00	1.2
KAFB#3	110.7	<1	>99%	7	10	0.00	1.1
CONTROL	93.6	93.8	0.2%	7	7	0.00	0.00

LEGEND

$[EN]_i$ = initial ethylenediamine concentration.

$[EN]_{18}$ = ethylenediamine concentration after 18 hours.

pH_i = initial pH.

pH_{18} = pH after 18 hours.

$O.D._i$ = initial optical density at 440 nm.

$O.D._{18}$ = optical density after 18 hours.

G. COLORED WATER IDENTIFICATION

The solution resulting from the reaction of sodium cyanide and sodium *m*-nitrobenzenesulfonate was acidified with conentrated hydrochloric acid to drive off the free cyanide. This aqueous solution was then analyzed using resonance Raman spectroscopy. This technique was hampered by an extremely strong background which could have been caused by unidentified fluorescent species in the solution. The data suggests that the aromatic ring and nitro groups were still intact but the sulfonate group was no longer present. This is curious since the nitro group should be more susceptible to nucleophilic substitution than the sulfonate group. This would seem to imply a mechanism other than nucleophilic substitution is operating in this reaction.

The further acidification of the stock solution (mentioned above) with concentrated hydrochloric acid yielded a white precipitate and a red solution. The red solution was analyzed by HPLC and the resulting chromatogram revealed 18 individual peaks. Due to the unexpected complexity of the spectrum coupled with time constraints, the red component was not identified. The precipitate was analyzed using HPLC and was identified as recovered starting material (sodium *m*-nitrobenzenesulfonate) by comparison of its elution time with that of an authentic sample.

The solvent extraction with toluene yielded a slightly discolored organic fraction. This was analyzed using GC-MS. Only a few peaks, of low intensity, were observed on the GC chromatogram. These were tentatively identified from the mass spectra as *o*-, *m*-, and *p*-nitrophenol. The formation of these species suggests a nucleophilic aromatic substitution reaction, however as previously mentioned, we would have expected the nitro group to be more substitution labile than the sulfonate group. Perhaps the reaction is under an unusual form of substitution control. Another explanation which also accounts for the different isomers is a benzyne intermediate, however this is unlikely since the reaction was conducted in aqueous solution. A more plausible explanation for the different isomers, especially since they were in low concentrations, is that the starting material was contaminated with more than one isomer of nitrobenzenesulfonate.

H. FLUID AGITATION

Observations and data from the flow tests using the polystyrene beads and from the dissolution tests using hard candies is given in Tables 11 and 12; 13 and 14; and 15 and 16, respectively for the one, two, and three legged manifold systems. The control tests for hard candy dissolution using calm water is shown in Table 17.

The one-legged manifold produced a rolling action in the tank as shown in Figure 7. The dissolution rate was generally higher with this configuration, seemingly because the whole solution was cycling around the tank with momentum, and not just being agitated. If parts placement can be achieved without baffling the rolling action of the solution, this configuration would provide the best mass transport performance. Alternatively, positioning in the center of the tank may provide better agitation under baffled conditions.

The two-legged manifold system provided a twin rolling action as pictured in Figure 7. This configuration provided the least effective agitation, as displayed in the dissolution test results. Solution movement occurred in the path of the jets and along the wall regions, with relative calmness between the walls and the jets. Therefore, the test samples were situated in regions of low net fluid movement.

The three-legged manifold system produced three regions of solution rolling activity which can be seen in Figure 7. Although this manifold operated with a good level of performance, it requires the largest energy input of the three configurations tested. Once again, this manifold system produced regions of high flow along the jet streams and along the wall surfaces, leaving relatively calm areas between the jets and the walls.

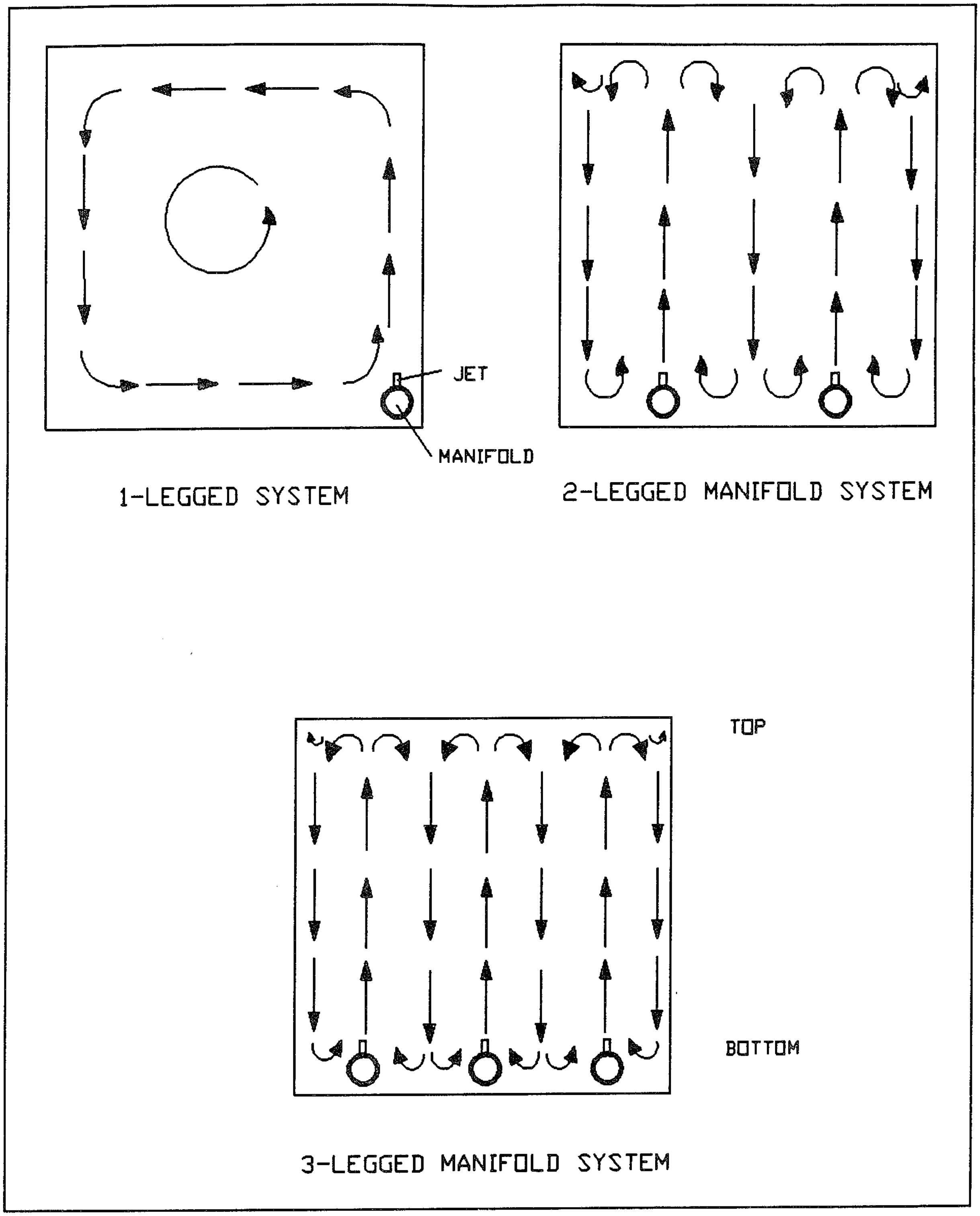

Figure 7. Current Flow for 1-, 2-, and 3-legged Manifold Systems.

TABLE 11. FLOW CHARACTERISTICS: ONE-LEGGED NOZZLE MANIFOLD.

Tank Section	Flow Description
1	Strong upflow enters from manifold and 2 then directs upward.
1′	Strong upflow enters from 1 then breaks at the top toward 2′.
2	Crossflow enters from 3 and moves horizontally toward 1.
2′	Crossflow enters from 1′ and moves horizontally toward 3′.
3	Downward flow enters from 3′ and moves horizontally toward 2.
3′	Flow enters from 2′ and moves downward toward 3.
4	Strong upflow enters from manifold and 5 then directs upward.
4′	Strong upflow enters from 4 then breaks at the top toward 5′.
5	Crossflow enters from 6 and moves horizontally toward 4.
5′	Crossflow enters from 4′ and moves horizontally toward 6′.
6	Downward flow enters from 6′ and moves horizontally toward 5.
6′	Flow enters from 5′ and moves downward toward 6.
7	Strong upflow enters from manifold and 8 then directs upward.
7′	Strong upflow enters from 7 then breaks at the top toward 8′.
8	Crossflow enters from 9 and moves horizontally toward 7.
8′	Crossflow enters from 7′ and moves horizontally toward 9′.
9	Downward flow enters from 9′ and moves horizontally toward 8.
9′	Flow enters from 8′ and moves downward toward 9.

Note: ′ indicates candy was at a depth of 8 inches vs normal 17 inches.

TABLE 12. CANDY DISSOLUTION TEST DATA: 1-LEGGED NOZZLE MANIFOLD.

Run Time - 4 minutes, Nozzle Supply Press. - 35 psig, Tank Temp - 25°C

Tank Position	Start Wt (g)	End Wt (g)	Wt Loss (g)
1	4.35	0.48	3.87
1′	3.99	0.27	3.72
2	5.22	LOST	LOST
2′	5.12	1.52	3.60
3	5.26	1.00	4.26
3′	5.27	1.77	3.50
4	4.53	LOST	LOST
4′	4.75	1.15	3.60
5	5.18	0.49	4.69
5′	5.08	1.22	3.86
6 outside	4.76	1.17	3.59
6′ outside	5.11	1.92	3.19
6 inside	5.19	1.16	4.03
6′ inside	4.93	0.86	4.07
7	5.22	LOST	LOST
7′	5.67	1.64	4.03
8	5.37	0.53	4.84
8′	5.02	1.36	3.66
9	4.70	LOST	LOST
9′	4.89	1.49	3.40

Note: ′ indicates candy was at a depth of 8 inches vs normal 17 inches.

TABLE 13. FLOW CHARACTERISTICS: 2-LEGGED NOZZLE MANIFOLD.

Tank Section	Flow Description
1	Strong upflow leaves the region along 1-2. Solution enters from the wall side of 1, the center of 2, and the manifold in the region bordering 1-2. Downflow in the tank corner.
1′	Strong upflow enters from 1 then breaks at the top toward 2 and the wall. Flow leaves the region along 1-2 and the corner.
2	Downflow enters from 2′ and splits toward 1 and 3.
2′	Crossflow enters from 1′ & 3′, then moves downward toward 2.
3	Strong upflow leaves the region along 2-3. Solution enters from the wall side of 3, the center of 2, and the manifold in the region bordering 2-3.
3′	Strong upflow enters from 3 then breaks at the top toward 2′ and the bordering wall. Solution moves downward at the bordering wall.
4	Strong upflow leaves the region along 4-5. Solution enters from the wall side of 4, the center of 5, and the manifold in the region bordering 4-5.
4′	Strong upflow enters from 4 then breaks at the top toward 5 and the wall. Flow leaves the region along 4-5 and the wall.
5	Downflow enters from 5′ and splits toward 4 and 6.
5′	Crossflow enters from 4′ & 6′, then moves downward toward 5.
6	Strong upflow leaves the region along 5-6. Solution enters from the wall side of 6, the center of 5, and the manifold in the region bordering 5-6.
6′	Strong upflow enters from 6 then breaks at the top toward 5′ and the bordering wall. Solution moves downward at the bordering wall.
7	Moderate upflow leaves the region along 7-8. Solution enters from the wall side of 7, the center of 8, and the manifold in the region bordering 7-8. Downflow in the tank corner.
7′	Moderate upflow enters from 7 then breaks at the top toward 8 and the wall. Flow leaves the region along 7-8 and the corner.
8	Downflow enters from 8′ and splits toward 7 and 9.

TABLE 13. FLOW CHARACTERISTICS: 2-LEGGED NOZZLE MANIFOLD (CONCLUDED).

8′	Crossflow enters from 7′ & 9′, then moves downward toward 8.
9	Moderate upflow leaves the region along 8-9. Solution enters from the wall side of 9, the center of 8, and the manifold in the region bordering 8-9. Moderate downflow in the corner increasing along the wall bordering 8-9.
9′	Moderate upflow enters from 9 then breaks at the top toward 8′ and the bordering walls. Solution moves downward at the bordering walls.

Note: ′ indicates candy was at a depth of 8 inches vs normal 17 inches.

TABLE 14. CANDY DISSOLUTION TEST DATA: 2-LEGGED NOZZLE MANIFOLD.

Run Time - 4 minutes, Nozzle Supply Press. - 35 psig, Tank Temp. - 19°C

Tank Position	Start Wt (g)	End Wt (g)	Wt Loss (g)
1	5.16	2.38	2.78
1′	5.07	2.21	2.86
2	4.76	2.65	2.11
2′	5.01	2.66	2.35
3	4.94	2.93	2.01
3′	5.33	3.50	1.83
4	4.82	LOST	LOST
4′	5.09	LOST	LOST
5	5.22	3.47	1.75
5′	4.75	2.53	2.22
6 inside	5.08	3.50	1.58
6 outside	4.76	2.72	2.04
6′ outside	5.44	2.64	2.80
6′ inside	5.31	2.85	2.46
7	5.04	0.64	4.40
7′	5.51	2.62	2.89
8	5.42	3.46	1.96
8′	4.95	LOST	LOST
9	4.78	2.21	2.57
9′	5.18	3.03	2.15

Note: ′ indicates candy was at a depth of 8 inches vs normal 17 inches.

TABLE 15. FLOW CHARACTERISTIC: 3-LEGGED NOZZLE MANIFOLD.

Tank Section	Flow Description
1	Strong upflow in center with solution entering from the walls, 1-2, and the manifold.
1′	Upflow in center of region with strong downflow at wall edges and on the 1-2 border.
2	Strong upflow in center with solution entering from the wall, 1, 3, and the manifold.
2′	Upflow in center of region with strong downflow at wall edge and on the 1 and 3 borders.
3	Strong upflow in center with solution entering from the walls, 2-3, and the manifold.
3′	Upflow in center of region with strong downflow at wall edges and on the 2-3 border.
4	Strong upflow in center with solution entering from the wall, 4-5, and the manifold.
4′	Upflow in center of region with strong downflow at wall edge and on the 4-5 border.
5	Strong upflow in center with solution entering from 4, 6, and the manifold.
5′	Upflow in center of region with strong downflow at 1 and 3 borders.
6	Strong upflow in center with solution entering from the wall, 5-6, and the manifold.
6′	Upflow in center of region with strong downflow at wall edge and on the 5-6 border.
7	Strong upflow in center with solution entering from the walls, 7-8, and the manifold.
7′	Upflow in center of region with strong downflow at wall edges and on the 7-8 border.
8	Strong upflow in center with solution entering from the wall, 7, 9, and the manifold.
8′	Upflow in center of region with strong downflow at wall edge and on the 7 and 9 borders.

TABLE 15. FLOW CHARACTERISTIC: 3-LEGGED NOZZLE MANIFOLD (CONCLUDED).

9	Strong upflow in center with solution entering from the walls, 8-9, and the manifold.
9′	Upflow in center of region with strong downflow at wall edges and on the 8-9 border.

Note: ′ indicates candy was at a depth of 8 inches vs normal 17 inches.

TABLE 16. CANDY DISSOLUTION TEST DATA: 3-LEGGED NOZZLE MANIFOLD.

Run Time - 4 minutes, Nozzle Supply Press. - 35 psig, Tank Temp. - 19°C

Tank Position	Start Wt (g)	End Wt (g)	Wt Loss (g)
1	5.35	1.54	3.81
1′	4.81	2.55	2.26
2	5.09	0.66	4.43
2′	4.93	2.47	2.46
3	5.11	2.01	3.10
3′	5.05	2.36	2.69
4	5.50	2.55	2.95
4′	4.97	2.26	2.71
5	4.75	LOST	LOST
5′	4.85	2.11	2.74
6 inside	5.35	1.11	4.24
6 outside	4.68	1.10	3.58
6′ outside	5.15	2.81	2.34
6′ inside	5.24	2.40	2.84
7	5.03	0.83	4.20
7′	4.78	1.86	3.02
8	5.22	0.54	4.68
8′	5.24	2.19	3.05
9	5.48	2.32	3.16
9′	4.78	2.17	2.61

Note: ′ indicates candy was at a depth of 8 inches vs normal 17 inches.

TABLE 17. CANDY DISSOLUTION CONTROL TESTS: STILL WATER.

Water Temperature 17°C (63°F)

Candy Number	Run Time (minutes)	Start Weight (grams)	End Weight (grams)	Wt Loss (grams)
1	4	5.1210	4.4292	0.6918
2	4	4.1535	3.5022	0.6513
3	4	4.1362	3.5307	0.6055
4	5	4.7559	3.8937	0.8622
5	5	4.8459	3.9714	0.8745
6	5	4.7840	4.0885	0.6955
7	15	4.5241	2.2295	2.2946
8	15	4.7367	2.6675	2.0692
9	15	4.9785	2.7709	2.2076
10	15	4.6358	2.5481	2.0877

SECTION V
CONCLUSIONS

A. IMPLEMENTATION OF NICKEL STRIPPERS

Two noncyanide strippers which performed well in field tests during Phase II (FY 89) were implemented during Phase III (FY 90) and include: CLEPO 204 (Frederick Gumm Chemical Company, Inc.) and Nickel-Sol (Electrochemicals).

1. CLEPO 204 (Frederick Gumm Chemical Company, Inc.)

CLEPO 204 offers the best combination of stripping rate for electrolytic nickel plates and low-alloy steel basis metal protection for any commercial formulation tested. It offers stripping rates around 2 milli-inches per hour at initial make-up and has a service lifetime in excess of two and a half months as determined by implementation testing. It works efficiently for removal of electrolytic nickel, but this is its only application since it is very poor at removing electroless nickel deposits. It does however, remove electrolytic nickel from all of the ferrous basis metals we tested. It even affords some protection to copper and copper alloy basis materials.

This stripper also worked well in applications where the parts required a wax masking material during the stripping operation as determined in Phase II. CLEPO 204 provides excellent stripping rates at lower temperatures, does not degrade the wax maskant material, and affords a good production rate. The implementation of this stripper into the Kelly AFB plating shop also met goals, such as, increased worker safety through the elimination of cyanide, reduced waste generation as a result of a longer service lifetime, less maintenance required due to increased bath stability, and complete compatibility with existing process equipment.

CLEPO 204 does pose problems since the IWTP at Kelly AFB does not have the ability to treat the organic components in this stripper (see

Biological Laboratory Tests Section below). This does not mean that they are not biodegradable, it simply means that work needs to be performed to enhance the capabilities of the existing wastewater treatment facilities to be able to fully degrade these chemicals. This is the reason that the biological support work is being pursued. Until a waste treatment scheme can be developed to treat these new organic chemicals, the use of this stripper must be restricted. When the waste treatment problem can be corrected, this stripper may be used full-scale for removal of electrolytic nickel plates from all ferrous basis metals.

Based on the implementation and field-test results obtained for CLEPO 204, this product is deemed a superior substitute for the Air Force's cyanide immersion nickel stripper (T.O. 42C2-1-7, Table 12-1, Step 3, C-106). Implementation of this product at other ALCs should not be a problem since most plating shops, while not engaged in the same workloads, have similar plating processes and all should be able to have their waste treatment schemes enhanced to accommodate the new organic wastes generated.

2. Nickel-Sol Process (Electrochemicals)

The Nickel-Sol Process is an incredibly fast stripper with rates over 10 milliinch per hour for most plate metals, but is limited to applications with stainless steel basis metals only. It is this excellent stripping rate which makes it difficult to recommend any other stripper for removing nickel plates from stainless steel parts. As part of the implementation procedure, aircraft parts were tested and showed excellent stripping performance and satisfactory basis metal protection.

Since this stripper is a strong acid, several stripped parts were analyzed by the Kelly AFB Metallurgical labs and it was determined that no anomalous attack (pitting, etching, etc.) was occurring on the surface of the parts. Nickel-Sol may require rigorous maintenance and analysis procedures, yet it is by far the easiest noncyanide stripper to treat for waste disposal. It merely requires the heavy metals to be precipitated and the remaining solution pH neutralized before disposal down a common sewer is permissible.

This stripper is compatible with the masking materials and operates at room temperature which negates any need for heating. It is non-volatile and therefore doesn't have any special ventilation requirements. It is also compatible with either air sparge, mechanical, or fluid agitation systems provided stainless steel or acid resistant plastic parts are used.

The implementation of this stripper was targeted to replace the Nitric Acid stripper which is currently in use at the Kelly AFB plating shop. This was because of the Nickel-Sol Process's excellent stripping rates (both electrolytic and electroless nickel), increased worker safety (through elimination of the noxious NO_x fumes evolved during the nitric acid stripping process) and reduced waste generation properties. While nitric acid is not a cyanide containing stripper, the minimal waste generation and increased worker safety of Nickel-Sol make it a superior substitute for the Air Force's Nitric Acid electroless nickel stripper (T.O. 42C2-1-7, Table 13-1, Step 3, C-120). One must always bear in mind that this application of Nickel-Sol must be used only on stainless steel parts.

B. FIELD TESTING OF NICKEL STRIPPERS

The number of strippers that have been tested in our labs expanded to over 30 this year with the number of field-tested nickel strippers increasing from five to eight. The three new products tested this year include: Enstrip N-190 (Enthone, Inc.), Ni-plex 100 (M&T Harshaw), and B-9 Nickel Stripper (MetalX, Inc.). The first stripper is ethylenediamine based while the other two are amino-acid based formulations. The two amino acid strippers show very similar performance characteristics both for plate and basis metals. The ethylenediamine-based stripper is similar to CLEPO 204, but CLEPO 204 has a slightly better stripping rate for electrolytic nickel plates. Each of these new strippers will be discussed individually below.

Based on the results of testing through Phase III, the best nickel strippers commercially available for Air Force applications can be ranked as shown in Table 18. The ranking is in decreasing order of preference.

TABLE 18. RELATIVE RANKING OF COMMERCIAL NONCYANIDE NICKEL STRIPPERS.

For stripping electrolytic nickel from low or high alloy steels

At operating temperatures below 57°C (135°F)
1. CLEPO 204
2. Enstrip N-190

At operating temperatures above 57°C (135°F)
1. MetalX B-9
2. Ni-plex 100

For stripping electroless nickel from stainless steels

At ambient temperatures
1. Nickel-Sol
2. Nitric Acid, 50 percent by volume

For stripping electroless nickel from low or high alloy steel

At operating temperatures 49-66°C (120-150°F)
1. MetalX B-9
2. Ni-plex 100

1. B-9 Nickel Stripper (MetalX, Inc.)

This stripper is a solid powder composed of amino acids and pH adjustment agents which are dissolved in water to prepare the operating solution. It showed an excellent stripping rate for electroless nickel (better than C-106; around 0.8 milliinch per hour) and also protects both low-alloy and stainless steels. The fact that the stripper is a solid means that maintenance of the solution should be minimal as the active ingredient would not evaporate out of the bath. This also means that odors in the plating shop should not be a concern, and that the existing ventilation and agitation systems should be adequate. Since this formulation contains amino acids, it is inherently biodegradable and should present no problem in the treatment of the waste solutions other than the possibility of increasing effluent nitrates and ammonia concentrations. Regeneration of the solution gave acceptable nickel-stripping rates while maintaining basis metal corrosion protection.

2. Ni-plex 100 (M&T Harshaw)

This alkaline powder is mixed with water to prepare the operating solution. It is composed of amino acids and sodium carbonate and is essentially the same formulation as B-9 Nickel Stripper (MetalX, Inc.). In fact, most of the stripping and corrosion test results almost exactly mimic those for B-9. Ni-plex 100 shows only fair stripping for electrolytic nickel plates, but shows excellent rates for electroless nickel deposits. It is safe for all ferrous substrates tested and is an excellent overall nickel-from-steel stripping formulation. But, it should be mentioned that it did not regenerate well. Since it is a powder, evaporation of the stripper does not occur. This negates the need for increased ventilation and means that the use of any type of solution agitation is possible. It is inherently biodegradable and any subsequent wastes can easily be dealt with.

3. Enstrip N-190 (Enthone Inc.)

This stripper is a two-component formulation (both a solid and a liquid) which is mixed with water to prepare the operating solution. It showed very good stripping rates for electrolytic nickel but poor rates for electroless nickel deposits and gave adequate corrosion protection to all ferrous basis metals tested. This stripper contains ethylenediamine and requires good ventilation and some maintenance analyses. The use of this stripper would be enhanced by fluid agitation since air sparge could strip the organic amine from solution. Work also needs to be done to make this formulation compatible with the IWTP at Kelly AFB. Since CLEPO 204 has been implemented and contains chemical ingredients which are similar to Enstrip N-190, a duplication of effort to implement this stripper is not recommended.

C. FIELD TESTING OF SILVER STRIPPERS

The three noncyanide, electrolytic silver strippers which were field tested during Phase III include McGean-Rohco Rostrip 999-SP, Technic Non-Cyanide Silver Stripper and Technic Cy-Less Electrolytic Gold Strip. The silver-stripping rate was excellent for Rostrip while the other two strippers

were significantly lower. Basis metal protection was afforded to almost all basis metals with the exception of Haynes 188 and Inconel 718 which were corroded by all strippers tested.

1. Rostrip Electrolytic Stripper 999-SP (McGean-Rohco, Inc.)

Rostrip 999-SP exhibited the best silver-stripping capability of the three tested with a stripping rate of 6-16 milliinches per hour. The best performing temperature was at 32°C as basis metals underwent pitting at the higher temperature (46°C). The pH of this stripper remained basic and was tested at values of 8, 11, 12, and 14. A pH of 8 provided the best silver-stripping rate, however, basis metal protection was sacrificed. Therefore, the best silver-stripping rate which maintained basis metal protection was in the pH range of 11-12. The current density recommended by the manufacturer provided the best combination of silver-stripping rate and basis metal protection. Increased current density increased basis metal corrosion and silver-stripping rates and the reverse occurred when the current density was decreased. When this stripper was loaded with 4 oz/gal (30 g/L) of silver, silver was still stripped at acceptable rates. Further research will need to be done to determine at what level the silver loading will lower the stripping rate below a value acceptable to the Air Force plating shop or 1 milliinch per hour.

2. Non-Cyanide Silver Stripper - Electrolytic (Technic Inc.)

The Non-Cyanide Silver Stripper had an average silver-stripping rate of 2 milliinches per hour, the lowest rate for the three strippers. The temperatures tested (32, 46, and 60°C) did not significantly affect basis metal protection or the silver-stripping ability of this stripper. The recommended pH of 10 provided the best silver-stripping rates and basis metal protection out of the tested pH range (9, 10, and 12). The highest pH tested (12) produced a slight increase in silver stripping but also greatly increased the corrosion rates of Haynes 188 and Inconel 718 basis materials. A change in current density provided little effect on the silver-stripping rate and basis metal protection, therefore, the current density recommended by the manufacturer is adequate.

3. Cy-Less Electrolytic Gold Strip (Technic Inc.)

Cy-Less Gold Strip had a good average silver-stripping rate of 8 milliinches per hour when run according to the manufacturer's recommended current-density. A variation in the operating temperature [32, 46, and 60°C (90, 115, 140°F)] had little affect on the silver-stripping capabilities, although corrosion decreased for Haynes 188 and Inconel 718 basis metals at the lowest temperature tested. The optimum temperature that provided good silver stripping and basis metal protection was at 32°C (90°F), a temperature that is even lower than that recommended by the manufacturer (46°C, 115°F). Of the pH range tested (3.0, 4.5, and 6.0), that recommended by the manufacturer (pH 4.5) provided the best silver-stripping rate and basis metal protection. Silver stripping was virtually unaffected by changes in pH. The higher pH values (4.5, and 6.0) provided excellent protection for all of the basis metals except Haynes 188, whose corrosion rate increased slightly at the higher pH but was unacceptable at all values. At pH 3.0, Inconel 718 joined Haynes 188 as the two basis metals with unacceptable corrosion rates. The current density recommended by the manufacturer provided the best combination of silver stripping and basis metal protection combination.

D. LABORATORY ELECTROCHEMICAL TESTS

Based upon test results, the following observations can be made: the best techniques for analysis of stripping solution components are dependent upon the component being tested. Cyclic voltammetry, which was used during Phase II (FY 89), may be used for testing of complexation agents and oxidizing agents. Overall formulations can be quickly screened using anodic potentiodynamic polarization but must be later tested using Tafel analysis to determine an accurate theoretical stripping rate. Those solutions with theoretical stripping rates similar to CLEPO 204 should then be tested by standard weight-loss techniques to determine actual plate metal stripping and basis metal corrosion rates.

The best generic stripping solution for electrolytic nickel plates has been determined to contain: ethylenediamine, nitric acid, sodium nitrate,

sodium *m*-nitrobenzenesulfonate, and ammonium thiocyanate. If this solution passes the corrosion tests, it should be field tested in preparation of implementation during the next fiscal year. The second best electrolytic nickel-stripping solution was tested for corrosion with zero weight-loss and no visual evidence of attack on C4340 low-alloy steel for a 24-hour immersion test. It contains the following ingredients: ethylenediamine, nitric acid, sodium nitrate, and sodium *m*-nitrobenzenesulfonate. This appears to be a good starting solution which may be adjusted by slight additions of activating ingredients to increase the stripping rate.

E. METAL CLEANING SOLUTIONS

While the vendor search for cyanide cleaner replacements was under way, Tinker AFB started replacing their cyanide cleaners with Endox Q576. Since Tinker AFB was the primary focus of this work and had already taken steps to eliminate their cyanide containing cleaning solutions, this Task was eliminated.

F. BIOLOGICAL LABORATORY TESTS

At the present time, the IWTP at Kelly AFB is not capable of fully degrading the organic chemicals contained in CLEPO 204. However, laboratory test results indicate that microorganisms already exist in the IWTP that can biodegrade ethylenediamine. Three microbial strains for ethylenediamine degradation have been isolated and identified. Further laboratory and pilot-plant testing of this work remain to be pursued.

G. COLORED WATER IDENTIFICATION

Unfortunately, the results from laboratory testing of a red colored solution representative of the C-106 process yielded too many products to allow for facile separation and the identification of the species responsible for the "red water" was not accomplished. There were several by-products of

the reaction which were identififed by GC-MS analysis (*o*-, *m*-, and *p*-nitrophenol). Unfortunately, the formation of these species in the reaction does not provide sufficient information to discern the reaction mechanism which may be responsible for the generation of the colored species.

H. FLUID AGITATION

The single-legged manifold system provided good agitation throughout the test tank and performed better than the two- and three-legged systems tested. The agitation provided by this system was sufficient to adequately and uniformly supply effective mass transfer in all regions of the tank. Additional testing is needed where sequential tests with the single-legged manifold can be conducted at different tank locations and with baffles in place to restrict the flow. Additionally, tests need to be conducted in full size tanks to gain information regarding power requirements for scaled-up operation.

SECTION VI
RECOMMENDATIONS

In fulfillment of goals established for this phase of work, the following recommendations are proposed. These recommendations are meant to aid in the incorporation of all significant accomplishments of the past year's work into ALC metal finishing operations and to provide a direction for future work.

A. IMPLEMENTATION OF NICKEL STRIPPERS

The following strippers completed implementation testing this year and are recommended for implementation throughout existing ALC operations. The products and their applications are given below:

- Electrochemicals' Nickel-Sol Process. Recommended for removing electrolytic and electroless nickel or copper coatings from heat and corrosion resistant steels and stainless steels. The product is an aqueous immersion stripper whose solution is composed of 10 percent sulfuric acid, an unknown amount of hydrogen peroxide, and proprietary additives. The process offers no resistance to common metals precipitation technologies for waste treatment and provides equivalent or better performance than cyanide or nitric acid solutions, without the evolution of noxious fumes. This product has also demonstrated the ability to soften the coatings present on augmenter liners as effectively as the nitric acid solutions currently in use.
- Frederick Gumm Chemical Company's CLEPO 204 Process. Recommended for removing electrolytic nickel coatings from low-alloy steel parts at temperatures at or below 55°C (130°F). The product is an ethylenediamine-based immersion stripper that provides good corrosion protection to low-alloy and stainless steels. This combination enables the stripping of electrolytic nickel from a variety of parts without the need to mask.

These processes should be incorporated into those ALCs that process any of the listed applications. As a result of favorable metallurgical results (Appendix Q), efforts should be made to either incorporate the products into the relevant Operating Technical Orders (Appendix R) or to obtain special purchasing agreements with the manufacturers.

The following strippers completed field testing this year and are recommended for implementation testing next year. The products and their applications are listed below:

- MetalX's B-9 for removing electroless nickel coating from low-alloy and stainless steels at temperatures around 65°C (150°F).
- M&T Harshaw's Ni-plex 100 as a backup for removing electroless nickel coatings from low-alloy and stainless steels at temperatures around 65°C (150°F).

B. IMPLEMENTATION OF SILVER STRIPPERS

One electrolytic process for stripping silver coatings from low-alloy steels and stainless steels is recommended for implementation testing as a replacement to currently used cyanide based strippers. This stripper contains operating conditions and certain restrictions that may limit its use.

- McGean-Rohco's Rostrip 999-SP is recommended for implementation and operation at 32°C (90°F), pH 11-12, and current density of 100 amperes per square foot. Two of the basis metals tested, Haynes 188 (a cobalt alloy) and Inconel 718 (a nickel alloy) exhibited surface degradation on prolonged exposure to the solutions. However, the fast silver-stripping rate coupled with the fact that other basis metals were adequately protected lead us to recommend this formulation.

C. FIELD TESTING AND IMPLEMENTATION OF GENERIC NICKEL STRIPPERS

Additional tests need to be conducted with generic electrolytic nickel strippers already developed in this program, and new generic strippers should be developed for copper, silver, and electroless nickel coatings.

- The basic nickel stripper containing ethylenediamine, nitric acid, sodium nitrate, and sodium *m*-nitrobenzenesulfonate should be field tested in the facility located on Kelly AFB.
- Additional laboratory tests should be conducted with the above mentioned solution, in conjunction with a wider variety of corrosion inhibitors and surface coating activators. It is very likely that additional generic formulations will result that service a wider coatings application base.
- There should be an effort made to incorporate the generic electrolytic nickel stripper into the appropriate Operating Technical Orders or otherwise make this new technology available to all of the ALCs. This will alleviate many purchasing difficulties between vendors with similar products that do not have components that can be cross mixed.

D. METAL CLEANING SOLUTIONS

It is uncertain whether cyanide metal cleaners continue to be used throughout the ALC complex. Recent commercial products have become available and are being continually implemented by ALC personnel at several of the facilities. This was previously an area of concern but now lacks definition. In most applications, cyanide cleaners are unnecessary and represent overkill for the cleaning jobs that need to be performed during most metal finishing operations. Cyanide is particularly desirable for removing heavily scaled or severely rusted surface impurities and imbedded particles. Since this is not representative of most of the parts that can be refurbished, alternate process solutions containing sodium hydroxide, phosphates, silicates, and/or complexing agents can and should be used. Each ALC should survey its service

applications, and correspondingly change its metal cleaning processes. Suggested alternatives include:

- Bead blasting of heavily scaled or rusted parts followed by cleaning in sodium hydroxide solutions or those listed as alternates to cyanide cleaning T.O. 42C2-1-7.
- Change to those alternates listed in T.O. 42C2-1-7 for general purpose cleaning.
- Implement commercial metal cleaners (the plating personnel at Tinker AFB have achieved considerable success at this and should be consulted).

It is also recommended that if a new cleaner is targeted for use, the cleaner should be tested for treatment compatibility at the Kelly AFB IWTP.

E. FEASIBILITY AND PILOT TEST FOR IMPROVED BIODEGRADATION OF WASTES

Several recommendations arise from the biological work begun in FY 90. Samples of the Kelly AFB IWTP activated sludge received cursory evaluation regarding the biodegradation of new organic wastes. These wastes were not previously present in the wastewaters in any significant concentrations, but will now occur because of the implementation of new generation products. Considerable testing is still required to turn the initial laboratory results into a technology rendering the IWTP at Kelly AFB capable of degrading virtually all of the waste organics evolved during metal finishing operations.

- The test facility under construction and located on the IWTP site at Kelly AFB should be completed.
- Laboratory tests need to be completed so that the physiological characteristics of the microorganisms can be ascertained. This applies to those microorganisms responsible for the degradation of ethylenediamine.
- Pilot-scale tests need to be initiated to demonstrate that the activated sludge system as a whole, and on a larger scale than the

lab, can be acclimated to these new food sources without deleteriously affecting the other desirable operating characteristics.

- All additional tests should be run at the Kelly AFB IWTP facility where samples of the sludge and wastewaters can be used directly in all of the future tests to insure transferability of the test results.
- Any test plans to conduct this work should include new calculations for dilution factor, activated sludge carbon loading factors, and contaminant concentrations that accurately reflect the conditions encountered at the IWTP.
- An effort should be made to identify any additional organics present in the wastewaters, in significant concentrations, so that acclimation of the sludge to these organic contaminants can also be evaluated.

F. COLORED WATER IDENTIFICATION

A recommendation of techniques to destroy the species responsible for the "red water" problem cannot be made at this time. This is due to the unexpected complexity of the reactions that occur in the C-106 process solution. We were unable to anticipate the large number of species generated during the reaction and the difficulty that would be encountered when attempts were made to separate/isolate the agents responsible for the coloration. We are recommending that a more intensive effort be given toward separation of the process solutions being implemented into the plating shop. This would mean discontinuing the investigation of the cyanide solutions (which were responsible for the initial concern with "red water" and are no longer in use) in favor of the noncyanide strippers. The number of reaction products resulting from the new solutions may be fewer and easier to separate.

G. FLUID AGITATION

We recommend that fluid agitation systems be considered for implementation since they offer reduced emissions of volatile organic chemicals (VOCs) from plating and stripping solutions, are able to incorporate filtering systems for purification (which extends bath lifetimes), and offer excellent flow characteristics within the tank.

Future development work on a fluid agitation system should concentrate on the following:

- Any nozzle manifold arrangement should be located so that the jets from the nozzles impinge as directly as possible upon the equipment being stripped or soaked. This would not necessarily be true for plating solutions, however.
- Alternatively, nozzle positions inducing the greatest amount of net fluid movement (displacement) should be incorporated.
- Nozzles should be installed so that flow comes from the bottom of the tank as well as from underneath the parts.
- The number of nozzles should be minimized, while ensuring that enough are used to adequately cover all flow directions. For a given pump, a lower number of nozzles would result in increased supply pressure at each nozzle and this would also improve the flow velocity around the nozzle.
- Nozzles should be grouped closely together when possible. This cuts down the pressure loss for the individual jets as they pass through the tank. The jets tend to stream together, concentrating their effects and better enabling them to reach any object in the bath.

Future development and testing of more sophisticated systems should be incorporated into future programs. These projections should incorporate feasibility analysis and testing of filtering components and solution maintenance systems in addition to the basic fluid agitation system. Particular attention should be directed toward precious metal plating bath maintenance and carbonate removal, and upon electroless metal deposition baths. These solutions are easy to target since they are expensive to prepare

and maintain and any extension of their useful lifetime translates directly into cost savings.

SECTION VII

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APPENDIX A

STRIPPERS TESTED DURING PHASES I-II

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AIR FORCE PROCESSES

Manufacturer	Product	Metal Tested	Test Conditions
Air Force Process C101	Cyanide Stripping Electrolytic	**PHASE I:** Cadmium, fuming bronze, indium, lead, nickel, silver, tungs-carb., LAS, SS	Electrolytic Lab
		PHASE II: Copper, nickel	Electrolytic Lab
Air Force Process C106	Cyanide Stripping Immersion	**PHASE I:** Cadmium, copper fuming bronze, indium, lead, nickel, silver tungs-carb., LAS, SS	Immersion Lab
		PHASE II: Nickel, Ni-S	Immersion Lab
Air Force Process	Nitric Acid Stripping Solution	**PHASE I:** Inconel, LAS, SS	Immersion Lab

COMMERCIAL PRODUCTS

Manufacturer	Product	Metals Tested	Test Conditions
Allied-Kelite Div., Witco Corp. 2400 East Devon Ave. Des Plaines, IL 60018 (708) 297-3570	ARP-60	**PHASE I:** Copper, indium, lead, nickel, silver, tin, LAS	Immersion Lab
Allied-Kelite Div., Witco Corp. 2400 East Devon Ave. Des Plaines, IL 60018 (708) 297-3570	ARP-66	**PHASE I:** Cadmium, copper, indium, lead, nickel, LAS, SS	Immersion Lab
		PHASE II: Copper, fuming bronze, nickel, Ni-S, LAS	Immersion Lab
Circuit Chemical Corp. 5129 Industrial Street Maple Plain, MN 55359 (612) 479-2008	Cirstrip NCN-Cu	**PHASE I:** Aluminum, chromium, copper, Hastelloy-X, Inconel, indium, lead, nickel, silver, tin, LAS, SS	Immersion Lab
		PHASE II: Cadmium, copper, fuming bronze, Ni-S, LAS, SS	Immersion Lab & Field

COMMERCIAL PRODUCTS

Manufacturer	Product	Metals Tested	Test Conditions
Circuit Chemical Corp. 5129 Industrial Street Maple Plain, MN 55359 (612) 479-2008	Nicstrip NCN-SCB	**PHASE I:** Cadmium, copper, fuming bronze, lead, nickel, silver, tin, tungs-carb., LAS, SS	Immersion Lab
Electrochemicals 751 Elm Street Youngstown, OH 44502 (216) 746-0517	Electrostrip S.A.	**PHASE I:** Cadmium, chromium, indium, lead, nickel, silver, tin, LAS **PHASE II:** Nickel, LAS, SS	Electrolytic Lab Electrolytic Lab
Electrochemicals 751 Elm Street Youngstown, OH 44502 (216) 746-0517	Nickel-Sol	**PHASE I:** Aluminum, cadmium, copper, fuming bronze, nickel, tungs-carb., LAS, SS **PHASE II:** Copper, Inconel, Ni-P, Ni-S, LAS, SS	Immersion Lab Immersion Lab & Field
Frederick Gumm Chemical Co. 538 Forest Street Kearney, NJ 07032 (800) 223-4866	CLEPO 204	**PHASE I:** Cadmium, copper, fuming bronze, indium, nickel, silver, tin, tung-carb., LAS, SS **PHASE II:** Copper, Inconel, Ni-P, Ni-S, LAS, SS	Immersion Lab Immersion Field
Frederick Gumm Chemical Co. 538 Forest Street Kearney, NJ 07032 (800) 223-4866	CLEPO Electrostrip B/C	**PHASE I:** Cadmium, chromium, copper, indium, lead, nickel, LAS, SS	Electrolytic Lab
Kiesow International 201 Greer Drive Mauldin, SC 29662 (803) 963-5808	Nickel Stripper ST	**PHASE I:** Cadmium, indium, lead, nickel, silver, LAS, SS **PHASE II:** Silver, LAS, SS	Electrolytic Lab Electrolytic Lab
MacDermid, Inc. 526 Huntington Ave. Waterbury, CT 06708 (203) 525-5700	Metex Electrolytic Rack Stripper SS-10	**PHASE II:** Silver, LAS, SS	Electrolytic Lab

COMMERCIAL PRODUCTS

Manufacturer	Product	Metals Tested	Test Conditions
MacDermid, Inc. 526 Huntington Ave. Waterbury, CT 06708 (203) 525-5700	Metex Metal Stripper SS-2	**PHASE II:** Silver, LAS, SS	Immersion Lab
MacDermid, Inc. 526 Huntington Ave. Waterbury, CT 06708 (203) 525-5700	Metex Nickel Stripper SCB	**PHASE I:** Cadmium, copper, fuming bronze, indium, nickel, tin, tungs-carb., LAS, SS	Immersion Lab
MacDermid, Inc. 526 Huntington Ave. Waterbury, CT 06708 (203) 525-5700	Metex Nitra-Add 3645	**PHASE II:** Silver, LAS, SS	Immersion Lab
MacDermid, Inc. 526 Huntington Ave. Waterbury, CT 06708 (203) 525-5700	Metex Silver Stripper CB	**PHASE I:** Copper, fuming bronze, nickel, silver, LAS, SS	Immersion Lab
McGean-Rohco, Inc. 1250 Terminal Tower Cleveland, Ohio 44113 (216) 441-4900	Rostrip Electrolytic Stripper 999-SP	**PHASE II:** Silver, LAS, SS	Electrolytic Lab
Metalline Chemicals Corp. 10620 North Port Washington RD Mequon, WI 53092 (414) 241-3200	Nickel Stripper 6400	**PHASE I:** Cadmium, fuming bronze, nickel, LAS, SS **PHASE II:** Cadmium, nickel, LAS	Immersion Lab
Metalline Chemicals Corp. 10620 North Port Washington RD Mequon, WI 53092 (414) 241-3200	Stripper 672	**PHASE I:** Cadmium, chromium, copper fuming bronze, lead, nickel, tin, tungs-carb., LAS, SS	Immersion Lab
Metalline Chemicals Corp. 10620 North Port Washington RD Mequon, WI 53092 (414) 241-3200	Zinc Stripper ST-W	**PHASE I:** Cadmium, chromium, copper, fuming bronze, indium, nickel, tin, tungs-carb., LAS, SS	Immersion Lab

COMMERCIAL PRODUCTS

Manufacturer	Product	Metals Tested	Test Conditions
Oakite Products, Inc. 50 Valley Road Berkeley Heights, NJ 07922 (201) 464-6900	Oakite Deoxidizer 104/105	**PHASE II:** Silver, LAS, SS	Immersion Lab
Oakite Products Inc. 50 Valley Road Berkeley Heights, NJ 07922 (201) 464-6900	Oakite Stripper Q9	**PHASE II:** Silver, LAS, SS	Electrolytic Lab
OMI International Corp. 21441 Hoover Road Warren, MI 48089 (313) 497-9129	Oxystrip 6000	**PHASE I:** Aluminum, cadmium, chromium, fuming bronze, nickel, tungs-carb., LAS, SS	Immersion Lab
OMI International Corp. 21441 Hoover Road Warren, MI 48089 (313) 497-9129	Udylite Immersion Stripper 406	**PHASE I:** Cadmium, chromium, copper, fuming bronze, nickel, silver, tungs-carb., LAS, SS	Immersion Lab
OMI International Corp. 21441 Hoover Road Warren, MI 48089 (313) 497-9129	Udylite Immersion Stripper 460	**PHASE I:** Cadmium, copper, fuming bronze, nickel, tin, tungs-carb., LAS, SS	Immersion Lab
OMI International Corp. 21441 Hoover Road Warren, MI 48089 (313) 497-9129	Udylite Immersion Stripper 460	**PHASE II:** Nickel, Ni-S, silver, LAS, SS	Electrolytic Lab
OMI International Corp. 21441 Hoover Road Warren, MI 48089 (313) 497-9129	Udylite Udystrip 7000	**PHASE I:** Cadmium, copper, fuming bronze, nickel, tin, tungs-carb., LAS, SS **PHASE II:** Ni-S	Electrolytic Lab Electrolytic Lab
OMI International Corp. 21441 Hoover Road Warren, MI 48089 (313) 497-9129	Udylite XPS-306 Immersion Nickel Stripper	**PHASE I:** Cadmium, copper, fuming bronze, nickel, tungs-carb., LAS, SS **PHASE II:** Cadmium, nickel, Ni-S, silver, tungs-carb., LAS, SS	Immersion Lab Immersion Lab

COMMERCIAL PRODUCTS

Manufacturer	Product	Metals Tested	Test Conditions
Patclin Chemical Co., Inc. 66 Alexander Street Yonkers, NY 10701 (914) 476-7000	Dip N Strip III	**PHASE I:** Cadmium, copper, fuming bronze, nickel, tungs-carb., LAS, SS	Immersion Lab
Patclin Chemical Co., Inc. 66 Alexander Street Yonkers, NY 10701 (914) 476-7000	Patstrip Ni	**PHASE I:** Cadmium, chromium, copper, fuming bronze, nickel, silver, tin, tungs-carb., LAS, SS **PHASE II:** Copper, Ni-P, Ni-S	Immersion Lab Immersion Field
Patclin Chemical Co., Inc. 66 Alexander Street Yonkers, NY 10701 (914) 476-7000	Patstrip Ni-E	**PHASE I:** Cadmium, chromium, copper, fuming bronze, nickel, tungs-carb., LAS, SS	Electrolytic Lab
Patclin Chemical Co., Inc. 66 Alexander Street Yonkers, NY 10701 (914) 476-7000	Patstrip #NiX-85	**PHASE I:** Aluminum, chromium, copper, fuming bronze, Hastelloy-X, nickel, LAS, SS **PHASE II:** Copper, Inconel, fuming bronze, nickel, LAS	Immersion Lab Immersion Lab
Technic, Inc. One Spectacle Street Cranston, RI 02910 (401) 781-6100	Cy-Less Electrolytic Gold Strip	**PHASE II:** Silver, LAS, SS	Electrolytic Lab
Technic, Inc. One Spectacle Street Cranston, RI 02910 (401) 781-6100	Non-Cyanide Silver Stripper	**PHASE II:** Silver, LAS, SS	Electrolytic Lab

LAS = Low-Alloy Steel
SS = Stainless Steel

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APPENDIX B

PRODUCT INFORMATION FOR COMMERCIAL NONCYANIDE STRIPPERS TESTED DURING PHASE III

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Electrochemicals / Circuit Chemistry

751 Elm Street
Youngstown, Ohio 44502
Telephone: 216/746-0517
Toll Free 800-321-9050
FAX: 216/743-3357

5129 Industrial Street
Maple Plain, Minnesota 55359
Telephone: 612/479-2008
FAX: 612/479-3451

PRODUCT INFORMATION DATA SHEET

ELECTROCHEMICALS NICKELSOL PROCESS

GENERAL DESCRIPTION

The Electrochemicals Nickelsol process is a hydrogen peroxide-sulfuric acid formulation designed to strip nickel and copper from aluminum, plastic and stainless steel.

The Nickelsol process can replace nitric acid strippers which cause the evolution of harmful NOx fumes.

The processing solution does not deteriorate to the point where it must be dumped. The copper and nickel dissolved can be recovered in the form of copper sulfate and nickel sulfate respectively.

The Nickelsol process does not contain cyanide or chelating agents and treatment of the subsequent rinse water is reduced to simple neutralization and precipitation.

The Electro-Brite Nickelsol process offers the following advantages:

1. Does not attack plastisol coatings.
2. The bath can be regenerated indefinitely, eliminating frequent dumping and the related waste treatment cost.
3. The economical recovery of the dissolved nickel and copper is made possible by crystallization.
4. The system, in most cases, is readily adaptable to most existing automatic, semi-automatic and manual operations.
5. Economy.
6. Simple control and maintenance.

The Electro-Brite Nickelsol process may be used in almost any industrial application where the removal of nickel and copper from base surfaces of aluminum, plastic and stainless steel is required. The bath composition can be adjusted to meet the specific operating requirements.

Some of the typical operations include:

A. Stripping electroless nickel from process tanks.

B. Stripping nickel and copper from stainless steel rack tips.

C. Stripping electroless copper from process tank.

D. Stripping of nickel and copper from plastic substrates.

E. Stripping of nickel and copper from aluminum substrates.

BATH MAKE-UP

A typical bath make-up for the Nickelsol process is as follows:

	Metals Stripped		
	Copper Only	Copper & Nickel	Nickel Only
H_2SO_4	10% v/v	10% v/v	10% v/v
Nickelsol I	12% v/v	12% v/v	12% v/v
CPX-II	2 lbs/100 gal	---	---
NSX	---	2 gal/100 gal	2 gal/100gal
$CuSO_4 \cdot 5H_2O$	2.0 oz/gal	2.0 oz/gal	2.0oz/gal

The following make-up procedure is recommended:

1. Add water to make up the tank to 50% of final working volume.

2. Stainless steel (300 series) equipment or when stripping off stainless steel base (see equipment) requires the addition of a minimum of 2 oz/gallon of copper sulfate ($CuSO_4 \cdot 5H_2O$). Dissolve completely.

3. While mixing, slowly add the required amount of 66^{o} Baume Sulfuric Acid. Do not let solution temperature exceed 140^{o}F.

4. Add required amount of CPX-II or NSX Stabilizer.

5. Add required amount of Nickelsol.

6. If necessary, add water to make-up the balance of the bath.

The exact bath composition may vary depending upon particular application. Our technical department is available for specific recommendations.

TYPICAL CYCLE

A typical cycle consists of:

1. Chrome removal (if necessary)
2. Water rinse
3. Electro-Brite Nickelsol process
4. Water rinse
5. Dry or Reprocess

OPERATION, CONTROL AND MAINTENANCE

Temperature	Room to 130^{o}F
Time (dwell)	As required
Agitation	Recommended (Air or Mechanical)
Stripping Rate Nickel	6 - 7 mil/hour
Stripping Rate Copper	9 - 10 mil/hour

The Electro-Brite Nickelsol process is composed of a dilute solution of sulfuric acid, a stripping agent and small quantities of proprietary stabilizing additives.

The primary stripping agent is Nickelsol I. Nickelsol I is a highly stabilized grade of hydrogen peroxide designed and specifically stabilized for use in Electro-Brite Nickelsol process. The usual concentration of Nickelsol I in the bath is 10 - 20% by volume. The exact concentration will be controlled by the speed of operation desired. Higher levels can result in faster stripping rates, all other conditions remaining the same. To minimize drag-out losses and provide the most economical operation, it is recommended that Nickelsol I be used at the lowest concentration that will produce the desired result. Nickelsol I should be controlled by analysis.

The consumption of Nickelsol I is directly related to the amount of copper or nickel removed during the stripping cycle and can be calculated with reasonable accuracy. For every pound of nickel metal stripped, 4.0 lb of Nickelsol I** is consumed. One pound of copper metal stripped consumes 1.68 lb of Nickelsol I. Per square foot of .001 inch thick deposit Nickelsol consumption is as follows:

Nickel: (.046 lb Nickel metal per mil sq. ft.)
.184 lb Nickelsol I consumed.

Copper: (.046 lb Copper metal per mil sq. ft.)
.077 lb Nickelsol I consumed.

**Nickelsol I weighs 10 pounds/gallon

Dwell or cycle time in the Electro-Brite Nickelsol solution is related to deposit thickness. Average time to strip 7 mils of nickel is 1 hour, but the solution can be adjusted for longer or shorter times. Normally, the less time available, the higher the Nickelsol concentration.

CPX-II and NSX Stabilizers provide a reserve against stabilizer drag-out losses and permits operation of the solution at higher temperatures. CPX-II is used when only copper is being stripped. Stripping of nickel requires the use of NSX Stabilizer instead of CPX-II. Both CPX-II and NSX Stabilizers are consumed. Daily additions should be made as follows:

Stabilizer	Daily Addition
NSX Stabilizer	.5 gal/100 gal
CPX-II Stabilizer	.5 lb/100 gal

The operation of the Nickelsol solution is slightly exothermic. The heat generated is normally very small and in most installations, is dissipated to the atmosphere. However, air agitation of the bath will help disperse this heat and is recommended to shorten immersion time, reduce Nickelsol consumption, and maintain bath uniformity. In installations where there is a high volume work load per gallon of Nickelsol solution, it may be necessary to provide some cooling. Therefore, it is recommended that a coil for heating and cooling be provided with a suitable temperature control, to allow control of temperature $\pm 5^{o}F$.

The operating temperature and temperature control are both extremely important to the successful operation of the Electro-Brite Nickelsol process. The greater the differential between operating and room temperature the easier nickel sulfate and copper sulfate can be removed by crystallization.

Nickel and copper sulfate accumulates in the bath during operation.

The performance of the bath is constant even when saturated. However, the nickel and copper sulfate will begin to crystallize when saturation is reached. Additionally crystallization will also take place when the temperature of the bath is reduced, since the ability to keep the nickel and copper sulfate in solution is temperature related. The lower temperatures have lower saturation levels.

Referring to the attached Curve #1, it can be seen that the saturation point for nickel sulfate ($NiSO_4 \cdot 6H_2O$) at 130°F is 90 oz/gal; at 80°F it is 52 oz/gal. By lowering the temperature of the stripping solution, containing 90 oz/gal at 130°F at 130°F, to 80°F, we can theoretically remove 38 oz/gal of nickel sulfate crystals. This crystallizing action does not take place at 100% efficiency bu it is sufficient enough to continuously remove nickel from the stripping solution, as nickel sulfate, and permit indefinite operation of the bath without dumping. Copper sulfate can also be crystallized in the same manner, see attached Curve #2 for saturation curve.

Copper and nickel are removed from the Nickelsol solution as copper sulfate pentahydrate ($CuSO_4 \cdot 5H_2O$) and nickel sulfate. At any given operating temperature there is a corresponding maximum copper and nickel concentration that the solution can hold, without the formation of copper and nickel sulfate crystals. While this concentration does not interfere with the stripping rate it can cause problems when it crystallizes in pumps, recirculating pipes, etc.

The nickel and copper can be controlled rather closely. When the Nickelsol bath approaches the saturation value for nickel and copper sulfate at any given operating temperature, the solution is transferred to another tank and allowed to cool to room temperature. Under these conditions, the excess copper or nickel will crystallize out as copper or nickel sulfate. Separating the Nickelsol solution, by decanting or pumping liquid back to the process tank, removes excess nickel or copper sulfate and regenerates the etching solution for re-use until it becomes saturated again.

Periodic cycling of the solution, in this manner, allows the solution to be operated indefinitely without dumping.

The Nickelsol process can also be operated continuously with a closed-loop recovery/regeneration system. This is achieved by continuously pumping the solution, at a fixed rate, through a recovery system where it is force cooled, the copper or nickel crystals separated, and the Nickelsol solution returned to process for further stripping.

Additional information on a continuous recovery/regeneration system is available upon request.

Reasonable control of the Nickelsol solution will result in stripping consistency, economy of operation, and minimize requirements for waste treatment.

Temperature, percent sulfuric acid, and Nickelsol concentration are the major factors that contribute to effective bath control. Since the temperature can be regulated automatically the sulfuric acid and Nickelsol I are the only factors that should concern production personnel. The concentration of both of these materials can be determined quickly and easily using the simple colorimetric titration procedures contained in this data sheet. These methods are designed so that inexperienced personnel can master them in a short time.

Maintenance chemical additions of Nickelsol may be made normally, but in installations where a high volume work load per gallon of Nickelsol solution exists, it may be more convenient to add the Nickelsol with a suitable metering pump. The stripping solution must not be allowed to siphon back into the Nickelsol I drum. Contamination with the stripping solution can cause rapid decomposition of Nickelsol I resulting in increased temperature and pressure within the drum which can cause the drum to rupture. Back siphoning can be effectively prevented by installing the discharge tube from the metering pump in such a way that it remains well above the surface of the stripping solution at all times.

EQUIPMENT

Tanks, tank linings, pumps, and other equipment should be recommended by the equipment supplier as being suitable for use with sulfuric acid 20% by volume and hydrogen peroxide 15% by volume.

Most 300 Series Stainless Steel equipment may be used to handle the bath provided the bath contains a minimum of 0.5 oz/gal of copper (2 oz/gal $CuSO_4 \cdot 5H_2O$). Passivation of the equipment with nitric acid will also improve resistance to corrosion. The mixing procedure outlined in this bulletin is recommended to minimize attack on stainless steel by the hot sulfuric acid solution during make-up.

Materials containing lead, tin, antimony, and bismuth or other heavy metals should NOT be used to handle the Electro-Brite Pickle Process solution.

The following list is intended as a guide and should not be considered complete.

TANKS

Reinforced fiberglass, polyethylene, polypropylene, stainless steel (300 Series), etc.

PUMPS

Circulation and transfer - stainless steel (300 Series), Duriron and many plastic and plastic-lined pumps.

Metering - should be constructed of stainless steel (300 Series) with diaphragms and check balls made from Teflon, Hypalon, Viton or equivalent.

Coils (heating and cooling) - 316 type "L" stainless steel, or Teflon. Maximum steam pressure 10 p.s.i.

Piping - PVDC, fiberglass (reinforced) or stainless steel (300 Series), polyethylene, etc.

Valves - (plug, gate, diaphragm) - stainless steel (300 Series), polyethylene, polypropylene, steel-coated with plasitsol or other suitable plastic.

When using low temperature plastics, such as polyethylene, be aware that these material soften at the normal operating temperature of the Electrochemicals Nickelsol process. Additional support should be provided in those cases where these materials are utilized.

2/19/88

NOTE: SULFURIC ACID SPECIFICATIONS

Sulfuric acid used with the Electrochemicals Nickelsol should be electrolyte grade.

Sulfuric Acid (as H_2SO_4)	93.19% min by weight
Specific Gravity at 60°F (15°C)	1.835 - 1.836

Contaminants should not exceed the below listed maximums:

Hydrochloric Acid (as HCl)	5 ppm
Nitrate (as NO_3)	5 ppm
Iron (as Fe)	42 ppm
Antimony (as Sb)	1 ppm
Selenium (as Se)	20 ppm
Manganese (as Mn)	0.2 ppm
Nickel (as Ni)	1 ppm

PROCESS CONTROL

Analysis for Sulfuric Acid and Nickelsol

TEST: Sulfuric Acid

PROCEDURE

1. Pipette a 1 ml sample of the Nickelsol solution into a 125 ml Erlenmeyer flask.

2. Add 2 to 5 drops of Methyl Orange Indicator.

3. Titrate with a 1.0 Normal Sodium Hydroxide (NaOH) solution to a yellow-green endpoint. (Solutions containing high concentrations of copper will form a dark precipitate at the endpoint).

4. Calculate the sulfuric acid concentration.

   cc's of 1.0N NaOH used x 2.8 = percent by volume sulfuric acid

TEST: Nickelsol

PROCEDURE

1. Pipette a 1.0 ml sample into 500 ml Erlenmeyer flask and add approximately 300 ml distilled or deionized water. Swirl to mix.

2. Add 5 ml of 50% by volume sulfuric acid solution and mix.

3. Add 1 ml Ferroin Indicator.

4. Titrate with standard Ceric Solution from pale red to pale blue.

5. Calculation

   cc's of standard Ceric Solution x .33 = percent by volume Nickelsol

REAGENTS

Sodium Hydroxide Solution: Dissolve 40.0 g Sodium Hydroxide, C.P., in distilled water and dilute to one liter (1.0N).

Methyl Orange Indicator: Dissolve 100 mg Methyl Orange in distilled water and dilute to 100 ml.

Ferroin Indicator: Mix 1.285 g 1,10-phenanthroline with 0.695 g ferrous sulfate heptahydrate and dissolve in 100 ml distilled or deionized water.

Standard Ceric Solution: 0.1N. Slowly add 30 ml concentrated sulfuric acid to 500 ml distilled water with constant stirring, then add 63.25 g of ceric ammonium sulfate dihydrate and stir until solution is complete, cool to room temperature, filter, if turbid, and dilute to exactly 1 liter in a volummetric flask.

PROCESS CONTROL

Analysis for Copper and Nickel

TEST: Copper in Nickelsol
(When only copper is being stripped)

REAGENTS

1. PAN Indicator: Dissolve 0.1 gram of PAN Indicator, 1-(2-pyridylazo)-2-naphthol in 100 ml alcohol.

2. Standard E.D.T.A. Solution: Dissolve 43.0 grams Disodium Ethylenediamine Tetraacetic Acid Dihydrate in 500 ml distilled water and dilute to 1 liter.

3. Ammonium Hydroxide: Concentrated, reagent grade.

4. Ammonium Persulfate: Crystals, reagent grade.

PROCEDURE

1. Pipette 1 ml sample solution to be tested into 250 ml Erlenmeyer flask.

2. Add 4 to 5 grams Ammonium Persulfate and agitate.

3. Let stand for several minutes until reaction is complete.

4. Add 12 ml Ammonium Hydroxide (solution turns blue).

5. Add 100 ml distilled water.

6. Add 5 drops PAN Indicator.

7. Titrate with Standard E.D.T.A. until color changes from purple to clear green.

8. Each ml of Standard E.D.T.A. = 0.95 oz/gal (7.13 g/l) copper metal

   3.80 oz/gal (28.5 g/l) copper sulfate (pentahydrate)

TEST: Analysis of Copper and Nickel in Nickelsol Solution (When copper and nickel are being stripped)

REAGENTS

1. 0.050 M EDTA - 18.6120 g/l of Disodium EDTA Dihydrate.
2. 0.050 M Zinc Nitrate - to 4.0685 g of reagent grade zinc oxide add 3.2 ml of Nitric Acid and 20 ml D.I. Water. When dissolved, dilute to 1 liter.
3. Murexide Indicator - 1% w/w in Sodium Chloride.
4. Xylenol Orange Indicator - 0.5% w/v in water.
5. Ammonium Hydroxide - 25% v/v
6. Hexamethylenetetramine
7. Potassium Fluoride

PROCEDURE

1. Pipette 1.0 ml of sample into a 250 ml flask. Add 100 ml D.I. Water and 10 ml Ammonium Hydroxide.
2. Add Murexide Indicator and titrate to a purple endpoint. Record mls used as A.
3. To a second 1.0 ml sample, add 1 gram Potassium Fluoride, 1 gram Thiourea, 1 gram Hexamethylenetetramine and 50 ml D.I. Water.
4. Add 30 mls of 0.050M EDTA and 7 drops Xylenol Orange Indicator. Back titrate with 0.050M Zinc Nitrate to a purple endpoint.

CALCULATIONS

Nickel

(ml EDTA x M EDTA) - (ml $ZnNO_3$ x $MZnNO_3$) = B

B x 35.05 = oz/gal Nickel Sulfate 6 Hydrate

Copper

(A x M EDTA) - B x 33.29 = oz/gal Copper Sulfate 5 Hydrate

When no copper is present follow only steps 1 and 2.

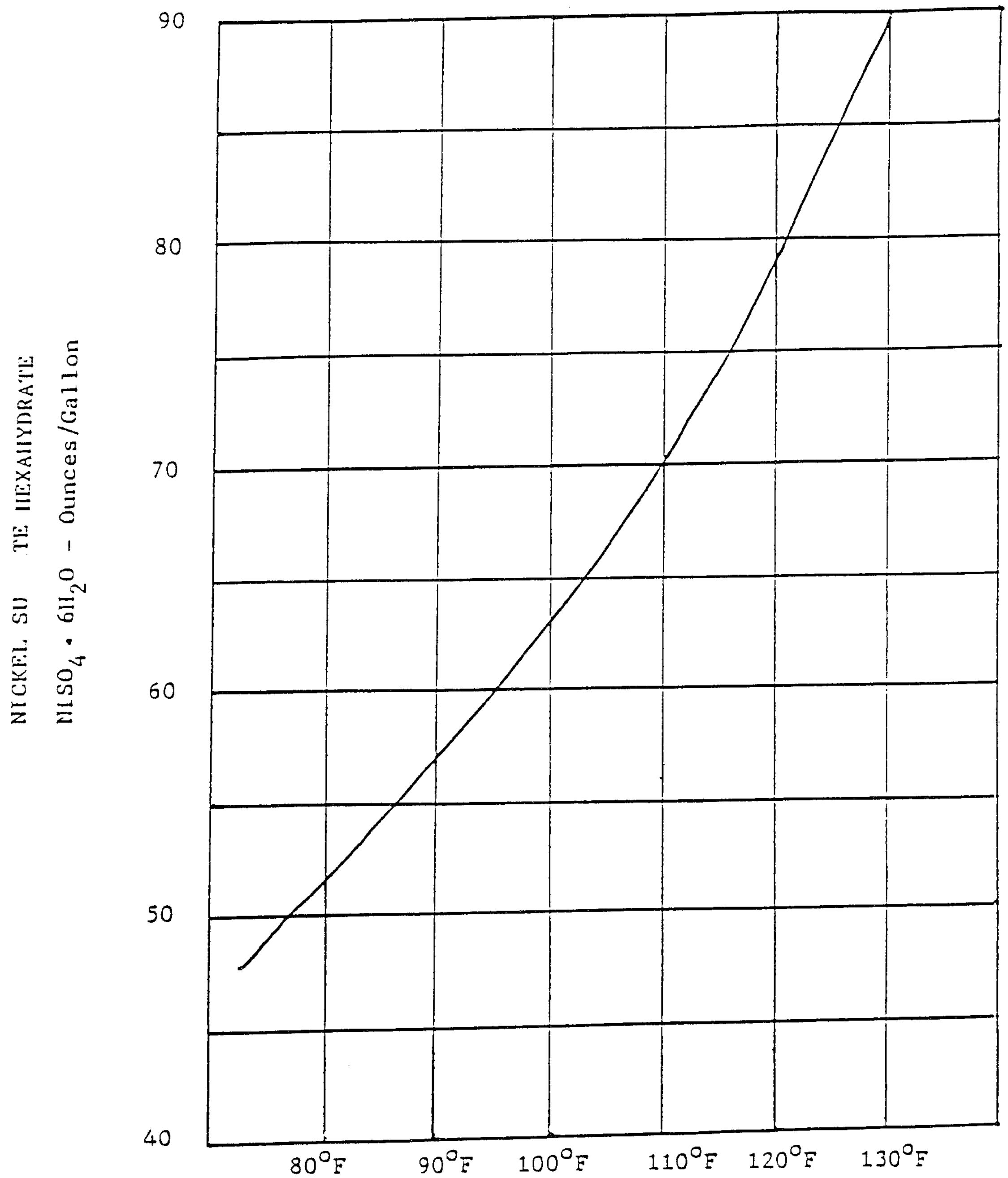
(A x M EDTA) x 35.05 = oz/gal Nickel Sulfate 6 Hydrate

A-RP-2305
2/19/88

NICKEL SATURATION CURVE

FOR

ELECTROCHEMICALS NICKEL-SOL PROCESS

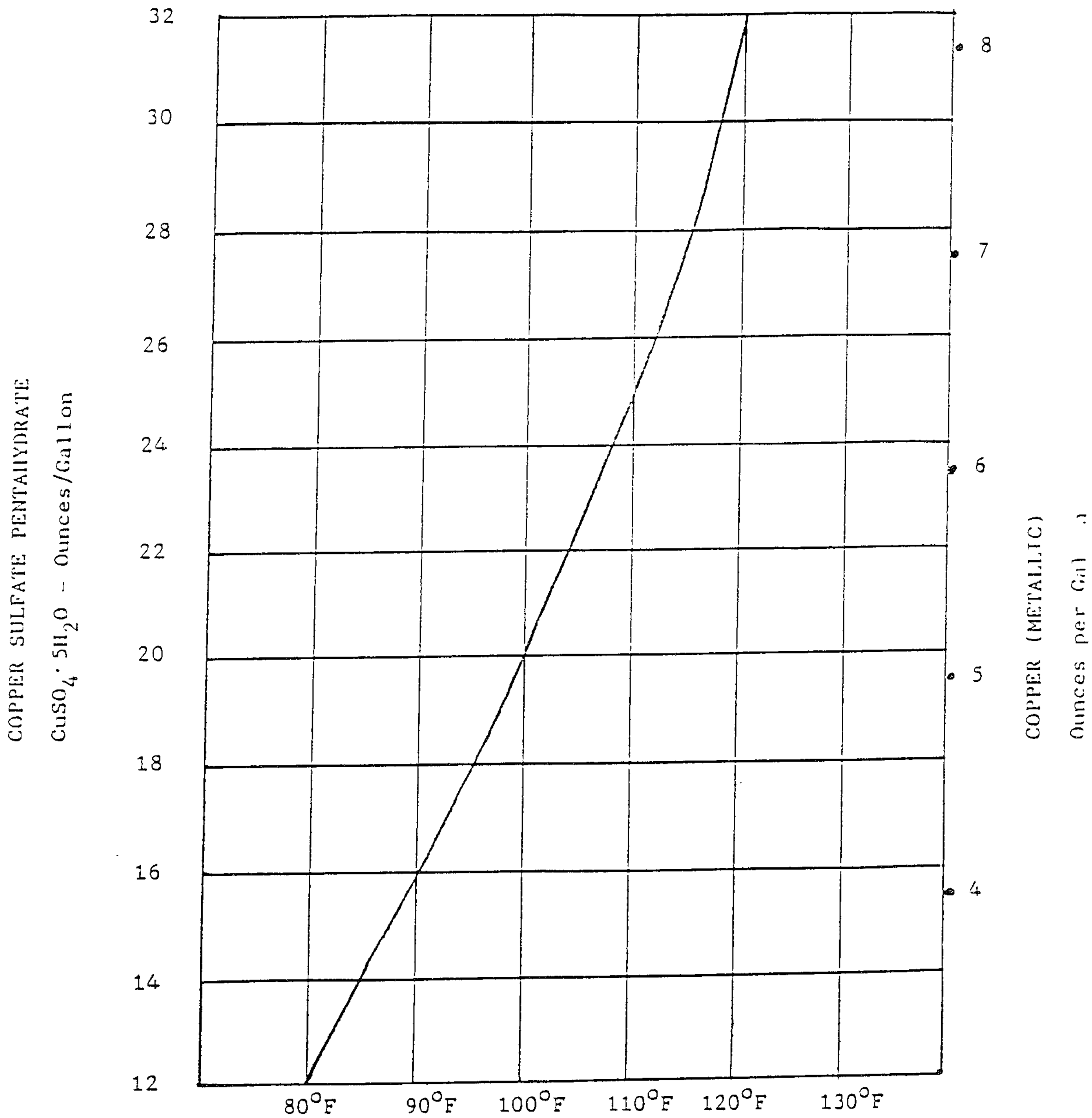


Curve 1

COPPER SATURATION CURVE

FOR

ELECTROCHEMICALS NICKEL-SOL PROCESS



Curve 2

CODE 2034

MATERIAL SAFETY DATA SHEET

ELECTROCHEMICALS
751 Elm Street
Youngstown, Ohio 44502
216-746-0517

1. PRODUCT NAME: ELECTRO-BRITE NICKELSOL I

2. PHYSICAL AND CHEMICAL CHARACTERISTICS

Boiling Point: 237 F
Specific Gravity: 1.20
Vapor Pressure: 18 mm Hg at 86 F
Stable: yes
Solubility in water: 100 %
Flash Point: N.A.
Flammable: no
Combustible: no
Extinguisher Media: N.A.

Special Fire Fighting Procedures: Releases oxygen when heated. Use water only on nearby fires.

Appearance and Odor: Clear colorless liquid, slightly pungent odor

3. HAZARDOUS INGREDIENTS

Ingredient	CAS No.	Wt.%	Hazard Type	Exposure Limit
Hydrogen peroxide	7722-84-1	40-52	Corrosive, Oxidizer	1 ppm (TLV)

Ingredients listed as carcinogens or potential carcinogens

Ingredients	NTP	IARC	OSHA

Primary Routes of Entry:
Skin and eye contact; inhalation of mist.

Signs and Symptoms of Exposure:
Contact with skin and eyes can cause severe burns. Mist may cause irritation of skin, eyes, and mucous membranes. Eyes are particularly sensitive, but effects may be delayed as much as a week or more after exposure. Ingestion may cause distension of stomach or esophagus and internal bleeding.

PRODUCT NAME: ELECTRO-BRITE NICKELSOL I

EMERGENCY AND FIRST AID PROCEDURES

EYES: Flush with water for 15 minutes and see physician.

SKIN: Flush with water and remove contaminated clothing. Contact physician in event of irritation.

INHALATION: Remove person to fresh air. Contact physician in event of irritation of throat or nose.

INGESTION: If patient is conscious, dilute with at least 2 glasses of water or milk. DO NOT induce vomiting. Obtain immediate medical attention.

5. PRECAUTIONS FOR SAFE HANDLING

Respiratory Protection (Type):
Canister type may be required in confined areas.

Ventilation:
Normally required with end use

Eye Protection:
Splash goggles or face shield.

Protective Gloves:
Rubber or vinyl

Other Protective Equipment:
Rubber apron, boots, safety shower.

Storage Precautions:
Store away from oxidizable and flammable materials and out of direct sunlight. Avoid chemical contamination in drums since contamination can cause rapid decomposition of peroxide resulting in bursting of drums.

Hazardous Decomposition Products:
Releases oxygen and intensifies fires.

Incompatibility With Other Materials:
Metals and metal salts, dirt, oxidizable materials, and organic compounds.

Steps to be Taken in Case of Spills or Leaks:
Dilute with large amounts of water and flush to sewer or waste treatment system.

DATE OF PREPARATION OR REVISION: May 11, 1989
This MSDS supersedes those dat Dec. 1, 1988 or earlier for this product. Such sheets are now obsolete and should be removed from your file

CODE 2104

MATERIAL SAFETY DATA SHEET

ELECTROCHEMICALS
751 Elm Street
Youngstown, Ohio 44502
216-746-0517

1. PRODUCT NAME: ELECTRO-BRITE CPX-II

2. PHYSICAL AND CHEMICAL CHARACTERISTICS

Boiling Point: N.A. Specific Gravity: N.A.
Vapor Pressure: unk mm Hg at
Stable: yes Solubility in water: 2 lb/gal
Flash Point: N.A. Flammable: no Combustible: no

Extinguisher Media: N.A.

Special Fire Fighting Procedures: N.A.

Appearance and Odor: White powder

3. HAZARDOUS INGREDIENTS

Ingredient	CAS No.	Wt.%	Hazard Type	Exposure Limit

This product contains no ingredients that are hazardous as defined by 29 CFR 1910.1200. However, it is still good practice to avoid excessive body contact and to rinse all spills immediately with water.

Ingredients listed as carcinogens or potential carcinogens

Ingredients	NTP	IARC	OSHA

Primary Routes of Entry:
Skin and eye contact.

Signs and Symptoms of Exposure:
Prolonged exposure may cause slight irritation of skin, eyes, and mucous membranes.

PRODUCT NAME: ELECTRO-BRITE CPX-II

CODE 2104

EMERGENCY AND FIRST AID PROCEDURES

EYES: Flush with water for 15 minutes and see physician.

SKIN: Flush with water and remove contaminated clothing. Contact physician in event of irritation.

INHALATION: Remove person to fresh air. Contact physician in event of irritation of throat or nose.

INGESTION: If patient is conscious, dilute by drinking two glasses of water. Induce vomiting and obtain immediate medical attention.

5. PRECAUTIONS FOR SAFE HANDLING

Respiratory Protection (Type):
Not normally required.

Ventilation:
No special requirements

Eye Protection:
Splash goggles or face shield.

Protective Gloves:
Rubber or vinyl

Other Protective Equipment:
Rubber apron

Storage Precautions:
No special requirements

Hazardous Decomposition Products:
May release oxides of sulfur and nitrogen when heated to dryness.

Incompatibility With Other Materials:
None reported.

Steps to be Taken in Case of Spills or Leaks:
Flush with water to waste treatment system.

DATE OF PREPARATION OR REVISION: Dec. 1, 1988

This MSDS supersedes those dated June 18, 1985 or earlier for this product. Such sheets are now obsolete and should be removed from your file.

CODE 2035

MATERIAL SAFETY DATA SHEET

ELECTROCHEMICALS
751 Elm Street
Youngstown, Ohio 44502
216-746-0517

1. PRODUCT NAME: ELECTRO-BRITE NSX STABILIZER

2. PHYSICAL AND CHEMICAL CHARACTERISTICS

Boiling Point: 220 F
Specific Gravity: 1.2
Vapor Pressure: unk mm Hg at
Solubility in water: 100 %
Stable: yes
Flash Point: N.A.   Flammable: no   Combustible: no

Extinguisher Media: N.A.

Special Fire Fighting Procedures: N.A.

Appearance and Odor: Colorless, odorless liquid

3. HAZARDOUS INGREDIENTS

Ingredient	CAS No.	Wt.%	Hazard Type	Exposure Limit
Phosphoric acid	7664-38-2	20-30	Corrosive	1 mg/m3 (TWA)

This product contains one or more substances subject to the reporting requirements of Section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 and 40 CFR 372. These substances and their concentrations are listed above.

Ingredients listed as carcinogens or potential carcinogens

Ingredients	NTP	IARC	OSHA

Primary Routes of Entry:
Skin and eye contact.

Signs and Symptoms of Exposure:
Contact will produce burns of skin, eyes, and mucous membranes.

PRODUCT NAME: ELECTRO-BRITE NSX STABILIZER

CODE 2035

EMERGENCY AND FIRST AID PROCEDURES

EYES: Flush with water for 15 minutes and see physician.

SKIN: Flush with water and remove contaminated clothing. Contact physician in event of irritation.

INHALATION: Remove person to fresh air. Contact physician in event of irritation of throat or nose.

INGESTION: If patient is conscious, dilute by drinking two glasses of water. DO NOT induce vomiting. Obtain immediate medical attention.

5. PRECAUTIONS FOR SAFE HANDLING

Respiratory Protection (Type):
Not normally required.

Ventilation:
No special requirements

Eye Protection:
Splash goggles or face shield.

Protective Gloves:
Rubber or vinyl

Other Protective Equipment:
Rubber apron

Storage Precautions:
Store away from alkaline materials.

Hazardous Decomposition Products:
Thermal decomposition may release toxic fumes of phosphorous oxides.

Incompatibility With Other Materials:
Metals and alkaline materials.

Steps to be Taken in Case of Spills or Leaks:
Neutralize with lime and flush to waste treatment system.

DATE OF PREPARATION OR REVISION: Dec. 1, 1988

This MSDS supersedes those dated Feb. 12, 1988 or earlier for this product. Such sheets are now obsolete and should be removed from your file.

ENTHONE
INCORPORATED
A subsidiary of ASARCO

MAILING ADDRESS: BOX 1900, NEW HAVEN, CT 06508
PLANTS: West Haven — Phone 203-934-8611
Chicago — Phone 312-598-3210
Los Angeles — Phone 213-537-0288
Toronto — Phone 416-677-1316

ENSTRIP® N-190

NON-CYANIDE STRIPPER FOR NICKEL FROM STEEL AND COPPER

BENEFITS OF USING ENSTRIP N-190

PROPERTIES	BENEFITS
Cyanide-free process	Eliminates use of costly sodium cyanide; eliminates cost of waste treatment to destroy cyanide
Contains no ammonia	No irritating ammonia fumes
No strong acids or caustic	Eliminates irritating mists
Two-component system (liquid and powder)	Ease of make-up; reduced storage space; reduced shipping costs for powder
Solution concentration can be standard or dilute	Economical stripping of large or small work loads

Enstrip N-190* is a non-cyanide, ammonia-free alkaline stripper that removes electroplated nickel deposits from steel, copper, and copper alloys by immersion. It will not attack soldering or brazing metals. A new standard operating solution of Enstrip N-190 strips at an initial rate of 1.2 mils (30 microns) of nickel metal per hour at 150°F. (66°C.); one gallon of a standard operating solution will dissolve approximately 2 to 4 oz. of nickel metal (15 to 30 g/l).

Enstrip N-190 is supplied as two materials that are mixed with water to make the operating solution. Enstrip N-190A is a liquid material and Enstrip N-190B is a powdered material. In addition, Enstrip Regenerator, a liquid material may be required to replenish the bath inhibitors and accelerators under certain circumstances.

*For the practice of the process of U.S. Patent No. 3,102,808.

HOW TO USE ENSTRIP N-190

OPERATING CONDITIONS

Concentration	
Enstrip N-190A	20% by volume
Enstrip N-190B	6 oz./gal. (45 g/l)
Water	As required
Temperature	150°F. (66°C.)
Time	As required

MAKE-UP

Add components in order given. Fill tank half full of water. Add required volume Enstrip N-190A; then add 6 oz./gal. (45 g/l) Enstrip N-190B and stir until dissolved. Add water to bring solution to final operating volume and heat solution to 150°F. (66°C.).

OPERATION

Parts to be stripped should be cleaned in an alkaline cleaner such as Enbond® S-61 or Enbond Q-527. Remove all chromium deposits with either an acid dip or an alkaline electrolytic cleaner such as Enbond 808. If an alkaline electrolytic cleaner is used, the parts should be dipped in a 30 to 50 percent by volume hydrochloric acid solution for one minute to activate the nickel surface. Follow with a running water rinse; then immerse the parts in the Enstrip N-190 operating solution.

Suspend the rack or basket of parts to be stripped into the Enstrip N-190 solution. Do not allow the parts to touch the bottom or sides of the tank or come in contact with the heating coils. For most efficient stripping, immerse as many parts as possible in the Enstrip N-190 solution. Mechanically agitate the work or solution to avoid localized overheating. **Do not use air agitation.** Remove all parts from the operating solution as soon as they are fully stripped.

Keep the stripping tank covered at all times. Prolonged operation of the solution without a cover will result in some loss of Enstrip N-190A. This loss must be replaced if efficiency is to be maintained. (refer to section entitled "CONTROL").

Ensure that copper, lead, chromium, and cadmium salts and/or metals are not introduced into the Enstrip N-190 solution. Contamination of the solution with these metals or salt will lower the stripping efficiency. New and used Enstrip N-190 solutions must not be heated for long periods without immersing nickel-plated parts into the solution. Metallic and organic contamination or heating without stripping nickel deactivates the accelerators in the Enstrip N-190 solution.

After the nickel has been stripped, the parts will be covered with a protective inhibitor film. This film can easily be removed by dipping the parts in a solution containing Endox® 114 at 1 lb./gal. (120 g/l) and sodium hydroxide 1 lb./gal. (120 g/l), at 100°F. (38°C.) with periodic reverse current (approximately 7 seconds anodic current, 4 to 5 seconds cathodic current).

The Enstrip N-190 bath is chemically balanced. When made-up and used as directed, both bath components will be exhausted at the same time. The spent solution may then be discarded and a new solution made-up. It is usually not economical to replenish the spent solution.

STRIPPING RATE

Although the Enstrip N-190 bath should be used at 150°F. (66°C.), it will strip nickel at room temperature, 72°F. (23°C.), at a rate of 0.1 to 0.25 mil (2.54 to 3.35 microns) per hour for a new bath. As the bath is used, it will become necessary to raise the temperature to maintain the stripping rate. The Enstrip N-190 bath should not be used cold. A new bath, operated at 150°F. (66°C.) will strip at a rate of 1.0 mil (25.4 microns) per hour. As the bath is used, the stripping rate will decrease. One gallon of Enstrip N-190 operating solution will dissolve approximately 2 to 4 oz. of nickel metal (15.0 to 30 g/l).

HOW TO USE ENSTRIP N-190 (DILUTE BATH)

The Enstrip N-190 dilute bath is used when large bulky pieces, or an accumulated backlog of parts requiring a large tank, are to be stripped. This dilute Enstrip N-190 bath is operated at a higher temperature and may prove more satisfactory and economical. The dilute bath will dissolve only one-half as much nickel as the standard Enstrip N-190 bath, but the stripping rate is about 1.5 times faster because of the higher operating temperature. This bath gives best results when it is used to exhaustion in not more than two working (down-time at room temperature not counted).

OPERATING CONDITIONS FOR DILUTE BATH

Concentration	
Enstrip N-190A	10% by volume
Enstrip N-190B	3 oz./gal. (22.5 g/l)
Water	As required
Temperature	176°F. (80°C.)
Time	As required

STRIPPING RATE OF DILUTE BATH

The stripping rate of a new, dilute Enstrip N-190 bath at 176°F. (80°C.) will be about 1.5 mils (38 microns) of nickel electroplate per hour. The stripping rate will decrease as the bath is used.

EQUIPMENT

Tanks made of steel or stainless steel are recommended for operating solutions of Enstrip N-190. The size of the tank is important; the tank should be deep enough to allow a maximum clearance between the bottom of the parts being stripped and the bottom of the tank to allow for any sludge accumulations. The stripping tank should be in a well-ventilated area. Exhaust ventilation is recommended.

Teflon heating coils or plain steel plate-coils are recommended for heating Enstrip N-190 solutions. Racks, hooks or baskets should be made of steel or stainless steel. Mechanical agitators are recommended for solution agitation. Mixer shaft and propeller should be plastisol-coated.

Tanks should be equipped with a steel, stainless steel or PVC plastic cover or polyethylene balls may be used to blanket the surface of the solution. A temperature controller is recommended.

The parts to be stripped and heating coils must be electrically insulated from the tank. All other equipment such as mechanical agitators, temperature sensors, in contact with the stripping solution must be free from any stray potential current capable of setting up a galvanic cell within the stripping solution.

CONTROL

Enstrip N-190 is chemically balanced so that if the solution is prepared and used as directed, all components will be exhausted and can be discarded simultaneously. However, continuous heating of the Enstrip N-190 solution without a cover or with a loose fitting cover will result in evaporation of some Enstrip N-190A. This loss must be made up by additions N-190A or premature exhaustion of the entire bath will occur. Additions of Enstrip N-190A must be accompanied by additions of Enstrip N-190B. Also, additions of Enstrip Regenerator may have to be made. **It is important to replenish Enstrip N-190A and N-190B before testing for the Enstrip Regenerator.**

The following procedures are recommended for analyzing and replenishing the Enstrip N-190 operating solution. Perform the analyses in the order given.

ANALYSIS FOR ENSTRIP N-190A

Apparatus Needed

5 ml pipette
50 ml burette
250 ml beaker
250 ml Erlenmeyer flask
Filter paper, Whatman #41

Reagents Needed

1% methyl orange indicator solution - dissolve 1 gram of methyl orange salt in 100 ml of deionized or distilled water.

1.0N sulfuric acid (H_2SO_4) solution - purchase from local laboratory supply house.

Procedure

1. Adjust the volume of the Enstrip N-190 operatig solution to volume at original make-up by adding water. Mix well.

2. Take a 150 ml sample of the adjusted operating solution, cool to room temperature and filter to remove particulate matter.

3. Pipette a 5 ml aliquot of the filtered solution into an Erlenmeyer flask and add 75 ml of deionized or distilled water and several drops of 1% methyl orange indicator solution.

4. Using a white background, titrate to the endpoint using 1.0N H_2SO_4 solution; color change is from yellow to pink.

Calculation

ml H_2SO_4 titrated x Normality H_2SO_4 x 1.13 = % by volume Enstrip N-190A in solution

Replenishment

Restore solution to original make-up of 10% by volume (for a dilute bath) or 20% by volume (for a full strength bath) Enstrip N-190A. Each 1% low in volume is equal to 1.28 fl.oz./gal. (10 ml/l); for each 10% by volume Enstrip N-190A replenished add 3 oz./gal. (22.5 g/l) Enstrip N-190B.

ANALYSIS FOR ENSTRIP REGENERATOR

The amount of Enstrip Regenerator required for replenishment is determined by a visual comparison of the Enstrip N-190 operating solution against several color standards.

Apparatus Needed

1 ml pipette - graduated in 0.1 ml units
2 ml pipette - dropper type
5 ml pipette - graduated in 0.5 ml units
10 ml pipette
20 ml pipette
10 ml graduated cylinder
100 ml volumetric flask (2 required)
1 liter volumetric flask
20 ml test tubes, stoppered (6 required)
1 White background

Reagents Needed

Copper sulfate solution - add 5 ml of ammonium hydroxide (NH_4OH) to 75 ml of water and dissolve 1.5 grams of copper sulfate pentahydrate ($CuSO_4 \cdot 5H_2O$) in the mixture. Add water to bring to exactly 100 ml. **Ensure that chemicals are added in order given or a solid will precipitate.**

1, 1, 2 - trichloroethylene or 1, 1, 2 trichloroethane - purchase from local laboratory supply house.

Standard Enstrip Regenerator solution - into a one liter volumetric flask pipette 0.70 ml of Enstrip Regenerator and dilute to exactly one liter with water.

Procedure

1. Number the test tubes 1 through 6.

2. Into each test tube place 10 ml of trichloroethylene or trichloroethane and 2 ml of copper sulfate solution. This results in the formation of two layers, blue on top and clear on the bottom.

3. Make the following additions to test tubes 1 through 5.

Test Tube No.	**ml of diluted Standard Enstrip Regenerator Solution**
1	none
2	1.0
3	1.5
4	2.0
5	2.5

Procedure (cont.)

4. Stopper each test tube and shake well. The bottom layers will take on varying shades of amber yellow, the top will remain blue.

5. Take a 150 ml sample of the Enstrip N-190 operating solution. **Ensure that the operating solution has been adjusted to recommended concentration of Enstrip N-190A and N-190B as outlined under "ANALYSIS FOR ENSTRIP N-190A."**

6. Allow sample to cool to room temperature; then filter to remove particulate matter.

7. Pipette 20 ml of the filtered N-190 operating solution into a 100 ml volumetric flask and dilute to exactly 100 ml.

8. Pipette 1 ml of the diluted Enstrip N-190 operating solution into test tube number 6; stopper and shake well.

9. Using a white background, compare the amber yellow color of the bottom layer of test tube number 6 against color standards number 1 through 5.

10. Use Graph I to determine the amount of Enstrip Regenerator to add to the Enstrip N-190 operating solution.

WASTE TREATMENT

The term "cyanide-free" is intended to denote that no cyanide chemicals are used in the manufacture of this product. This, however, does not preclude the possibility of a positive analytical result for cyanide due to interferences and impurities. Meaningful cyanide analysis requires that interferences be anticipated no matter what analytical method is employed. Any analytical questions about this product should be referred to your sales engineer or to Enthone's Technical Director.

Enstrip N-190 is an alkaline solution and must be neutralized to a pH of about 8.0 after treatment for nickel metal and prior to disposal into a sewage system. A detailed waste treatment procedure is available from Enthone's technical service department upon request.

Consult local agencies for regulations governing waste effluent disposal, especially with regard to nickel metal.

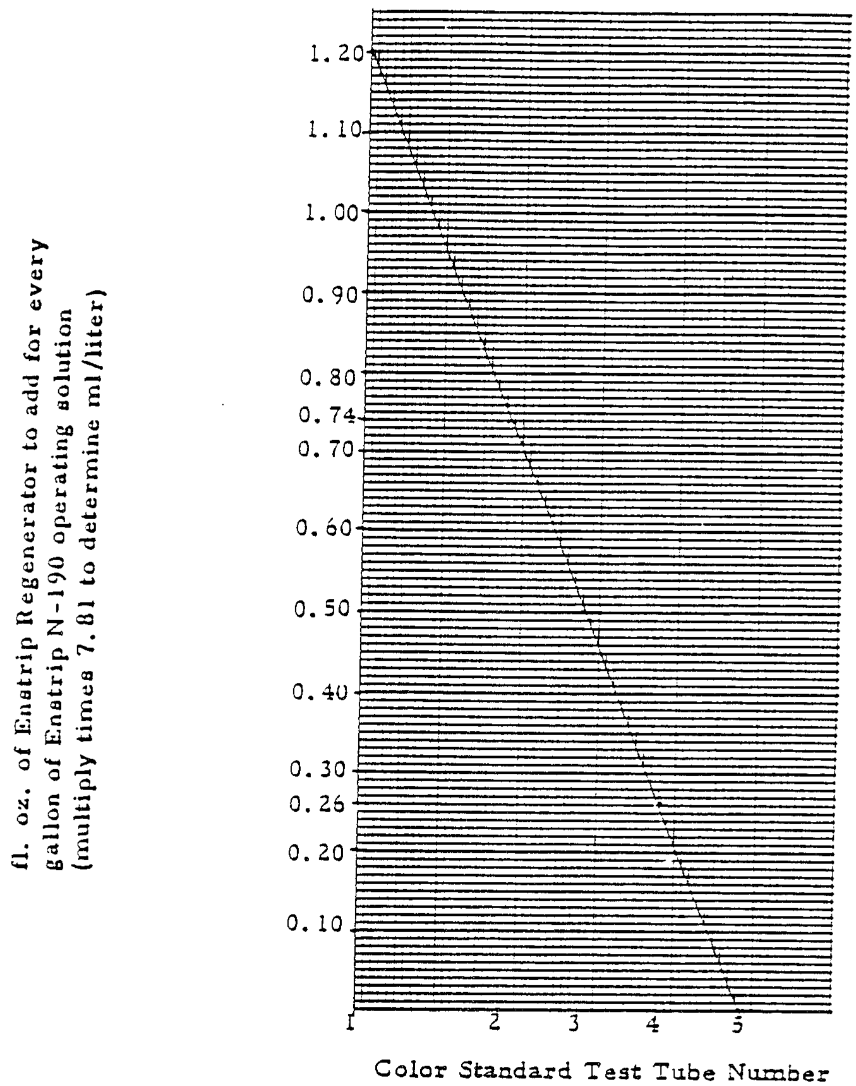
CAUTION

ENSTRIP N-190A AND THE ENSTRIP N-190 OPERATING SOLUTION ARE STRONGLY ALKALINE AND MAY CAUSE SKIN AND EYE BURNS. THE BATH COMPONENTS AND THE OPERATING SOLUTION SHOULD BE HANDLED WITH CARE, AND PROPER PROTECTIVE CLOTHING, FACE SHIELD, AND CHEMICAL SAFETY GLASSES SHOULD BE WORN TO PREVENT SKIN AND EYE CONTACT. DO NOT INHALE DUST OR MIST FROM THE BATH COMPONENTS OR FROM THE OPERATING SOLUTION. ENSTRIP N-190B SALTS ARE OXIDIZING IN NATURE. DO NOT ALLOW THEM TO COME IN CONTACT WITH ORGANIC MATERIALS SUCH AS SAWDUST, PAPER, CLOTH, WOOD, OR CHEMICAL REDUCING AGENTS BECAUSE OF THE POSSIBILITY OF FIRE.

IN CASE OF CONTACT WITH SKIN OR EYES, FLUSH WITH COOL, CLEAN WATER FOR 15 MINUTES; FOR EYES ALSO GET IMMEDIATE MEDICAL ATTENTION.

ISSUED: 6/1/85
SPSDS: 4/15/81

GRAPH I. DETERMINING REPLENISHMENT ADDITIONS OF ENSTRIP REGENERATOR FOR ENSTRIP N-190 OPERATING SOLUTIONS.



PROCEDURE: Determine color standard that best matches test tube number six. Read vertically to diagonal line then read horizontally (left) to determine fl. oz. /gal. of Enstrip Regenerator required.

EXAMPLE: Color test tube standard number 4 best matches test tube number six. Reading vertically and left, the operating solution should be replenished with 0.26 fl. oz. of Enplate Regenerator per gallon of operating solution (2.031 ml/liter).

Issued: 6/1/85
Spsds: 4/15/81

ENTHONE INCORPORATED

MATERIAL SAFETY DATA SHEET

ENSTRIP® N-190A

P.O. BOX 1900
NEW HAVEN, CT 06508

EMERGENCY PHONE NUMBERS			
PLANTS	203-934-8611	(8:30am-5pm EST)	PRODUCT CODE#: 2556
	312-598-3210	(8:30am-5pm CST)	DATE ISSUED: 1/13/88
MFSA	313-644-5626	(24 hours)	SUPERCEDES: 1/79
CHEMTREC	800-424-9300	(Transportation)	PREPARER: F.R. Hirtler

FRH

II. HAZARDOUS INGREDIENTS

COMPONENT	COMMON NAME	CAS NO.	OSHA-PEL	ACGIH-TLV	%
Water		7732-18-5	NI	NI	>45
Ethylenediamine	1,2-Diaminoethane	107-15-3	25mg/m3	25mg/m3	>45

III. PHYSICAL PROPERTIES

SPECIFIC GRAVITY (WATER =1)	1.010	BOILING POINT, °F	231
EVAP.RATE (BUTYL ACETATE=1)	NI	MELTING POINT, °F	<-40
VAPOR PRESSURE, mmHg	ca. 20	SOLUBILITY IN WATER	complete
VAPOR DENSITY (AIR=1)	NI	APPEARANCE	light yellow liquid
pH (AS IS)	>13	ODOR	ammoniacal

IV. FIRE AND EXPLOSION HAZARD DATA

FLASH POINT, °F	>100 (c.c.)	FLAMMABLE LIMITS (AIR)	NA	LEL	NA	UEL

EXTINGUISHING MEDIA

Not Combustible	Water fog or spray	Carbon Dioxide	Dry Chemical	Alcohol Foam	Foam	Sand or Earth
	X	X	X		X	

SPECIAL FIRE FIGHTING PROCEDURES

Wear NIOSH approved full protective clothing and self-contained breathing apparatus. Keep containers cool to prevent rupture and release of material.

UNUSUAL FIRE AND EXPLOSION HAZARDS

Heating dried salts to temperatures above 130°F may liberate toxic oxides of sulfur.

V. HEALTH HAZARD DATA

EFFECTS OF ACUTE EXPOSURE:

INHALATION: Mist or vapor may damage upper respiratory tract and lung tissue which may cause chemical pneumonia depending upon severity of exposure.

INGESTION: Can cause burns to mouth, throat, esophagus, and stomach.

SKIN: Can cause burns.

EYES: Causes severe burns with damage to eyes and possible blindness.

EFFECTS OF CHRONIC EXPOSURE:
May cause dermatitis and injury to liver, kidneys and lungs.

CARCINOGEN: Not listed by NTP, IARC, OSHA
REFERENCE:

EMERGENCY AND FIRST AID PROCEDURES

INHALATION: Remove person from contaminated area. If breathing has stopped, resuscitate and administer oxygen if available.
Seek immediate medical attention.

INGESTION: Never give anything by mouth to an unconscious person, obtain immediate medical attention. If vomiting occurs spontaneously, keep airway clear. If swallowed DO NOT INDUCE VOMITING, give large amounts of water.
Seek immediate medical attention.

SKIN: Immediately wash contaminated skin with plenty of water for 15 minutes. Remove contaminated clothing and footwear. Wash clothing before reuse. Discard footwear if it cannot be decontaminated.
Seek immediate medical attention.

EYES: Immediately flush eyes with plenty of water for at least 15 minutes holding lids apart to ensure flushing of entire surface. Washing eyes within several seconds of exposure is essential to minimize damage.
Seek immediate medical attention.

VI. PRECAUTIONS FOR SAFE HANDLING AND USE

SPILL PROCEDURES:

Avoid contact with skin, eyes, and clothing. Wear protective equipment (see Section VII). Do not breathe mist or vapors. Eliminate sources of ignition such as heat, sparks, and open flames. Ensure that the area is properly ventilated. Contain spill and soak up in suitable absorbent. Shovel up into plastic-lined steel containers and cover. Dispose of in accordance with Local, State, and Federal regulations.

STORAGE AND HANDLING PRECAUTIONS:

Store in a cool, dry place. Keep away from acids and oxidizers. Loosen cover cautiously when opening.

ADDITIONAL INFORMATION:

Vapors may travel to sources of ignition, distant from the point of handling.

VII. CONTROL MEASURES

VENTILATION: Local exhaust recommended.

RESPIRATOR: Use NIOSH approved respirator when air concentration is greater than the TLV or PEL.
Use cartridge filter for organic vapors.

EYE PROTECTION: [ ] Safety glasses [X] Chemical safety goggles [X] Face shield

PROTECTIVE GLOVES: [X] Neoprene [X] Natural rubber Other:

OTHER PROTECTIVE CLOTHING OR EQUIPMENT:

Chemically resistant coveralls, hat, and shoes or boots.

WORK/HYGENIC PRACTICES:

Emergency eye wash and safety shower should be available. Wash thoroughly after handling.

ADDITIONAL INFORMATION:

For waste disposal of operating solutions consult Enthone Waste Disposal Procedures. For major spills consult Enthone for disposal assistance. Dispose of in accordance with Local, State, and Federal regulations.

CAS = Chemical Abstract Service	PEL = OSHA Permissible Exposure Limit
NI = No relevant information available	TLV = ACGIH Threshold Limit Value
NA = Not applicable	NTP = National Toxicology Program
Trade Secret = Claimed as allowed under 29 CFR 1910.1200	IARC = Int'l Agency for Research on Cancer

VIII. REACTIVITY DATA

X	Stable	CONDITIONS TO AVOID: Stable under normal conditions. See Incompatibility information.
	Unstable	

INCOMPATABILITY (Materials to avoid): Oxidizing agents, acids, acid salts.

HAZARDOUS DECOMPOSITION PRODUCTS: Toxic oxides of nitrogen, carbon and sulfur.

HAZARDOUS POLYMERIZATION		May occur	CONDITIONS TO AVOID: NA
	X	Will not occur	

IX. ADDITIONAL INFORMATION

This Material Safety Data Sheet may be used to comply with OSHA's Hazard Communication Standard, 29 CFR 1910.1200. Enthone, Inc. furnishes the data contained herein in good faith at customer's request without liability or legal responsibility for same whatsoever, and no warranty or guarantee, express or implied, is made with respect to such data; nor does Enthone, Inc. grant permission, recommendation, or inducement to infringe any patent whether owned by Enthone or others. The data is offered solely for your information and consideration. Since conditions of use are beyond Enthone's control, user assumes all responsibility and risk.

ENTHONE
INCORPORATED

MATERIAL SAFETY DATA SHEET

ENSTRIP® N-190B

P.O. BOX 1900
NEW HAVEN, CT 06508

EMERGENCY PHONE NUMBERS			
PLANTS	203-934-8611	(8:30am-5pm EST)	PRODUCT CODE#: 2557
	312-598-3210	(8:30am-5pm CST)	DATE ISSUED: 8/24/87
MFSA	313-644-5626	(24 hours)	SUPERCEDES: 8/81
CHEMTREC	800-424-9300	(Transportation)	PREPARER: F.R. Hirtler FRH

II. HAZARDOUS INGREDIENTS

COMPONENT	COMMON NAME	CAS NO.	OSHA-PEL	ACGIH-TLV	%
p-Nitrobenzoic acid		62-23-7	NI	NI	100

III. PHYSICAL PROPERTIES

SPECIFIC GRAVITY (WATER =1)	1.55	BOILING POINT, °F	sublimes
EVAP.RATE (BUTYL ACETATE=1)	<1	MELTING POINT, °F	464-8
VAPOR PRESSURE, mmHg	NA	SOLUBILITY IN WATER	minimal
VAPOR DENSITY (AIR=1)	NA	APPEARANCE	light yellow crystals
pH (AS IS)	NA	ODOR	none

IV. FIRE AND EXPLOSION HAZARD DATA

FLASH POINT, °F	None	FLAMMABLE LIMITS (AIR)	NA	LEL	NA	UEL

EXTINGUISHING MEDIA

[ ] Not Combustible [X] Water fog or spray [X] Carbon Dioxide [X] Dry Chemical [ ] Alcohol Foam [ ] Foam [ ] Sand or Earth

SPECIAL FIRE FIGHTING PROCEDURES

Wear self-contained breathing apparatus (SCBA) and complete personal protective equipment when potential for exposure to vapors or products of combustion exists.

UNUSUAL FIRE AND EXPLOSION HAZARDS

Product will self-sustain combustion if ignited.

V. HEALTH HAZARD DATA

EFFECTS OF ACUTE EXPOSURE:	
INHALATION:	Can cause severe irritation.
INGESTION:	Can cause irritation to mouth, throat, esophagus, and stomach.
SKIN:	Can cause irritation.
EYES:	Can cause severe irritation, damage to eyes.

EFFECTS OF CHRONIC EXPOSURE:

Chronic exposure effects not established.

CARCINOGEN: Not listed by NTP, IARC, OSHA

REFERENCE:

EMERGENCY AND FIRST AID PROCEDURES	
INHALATION:	Remove person from contaminated area. If breathing has stopped, resuscitate and administer oxygen if available. Seek immediate medical attention.
INGESTION:	Never give anything by mouth to an unconscious person, obtain immediate medical attention. If vomiting occurs spontaneously, keep airway clear. If swallowed DO NOT INDUCE VOMITING, give large amounts of water. Seek immediate medical attention.
SKIN:	Immediately wash contaminated skin with plenty of water for 15 minutes. Remove contaminated clothing and footwear. Wash clothing before reuse. Discard footwear if it cannot be decontaminated. Seek immediate medical attention.
EYES:	Flush eyes with plenty of water, holding lids apart to ensure flushing of entire surface to prevent or relieve irritation. If irritation persists, seek medical attention.

VI. PRECAUTIONS FOR SAFE HANDLING AND USE

SPILL PROCEDURES:
Avoid contact with skin, eyes, and clothing. Wear protective equipment (See section VII). Sweep or shovel spilled material into clean plastic lined container and cover. Flush spill area with copious amounts of water. Dispose of in accordance with Local, State and Federal regulations.

STORAGE AND HANDLING PRECAUTIONS:
Store in a cool, dry place. Keep away from oxidizers. Loosen cover cautiously when opening.

ADDITIONAL INFORMATION:
Wash thoroughly after handling.

VII. CONTROL MEASURES

VENTILATION: Local exhaust recommended.

RESPIRATOR: Use NIOSH approved respirator when air concentration is greater than the TLV or PEL.
Use cartridge filter for dusts.

EYE PROTECTION: [X] Safety glasses [X] Chemical safety goggles [ ] Face shield

PROTECTIVE GLOVES: [X] Neoprene [X] Natural rubber Other:

OTHER PROTECTIVE CLOTHING OR EQUIPMENT:
Chemically resistant coveralls, hat, and shoes or boots.

WORK/HYGENIC PRACTICES:
Emergency eye wash and safety shower should be available. Wash thoroughly after handling.

ADDITIONAL INFORMATION:
For waste disposal of operating solutions consult Enthone Waste Disposal Procedures. For major spills consult Enthone for disposal assistance. Dispose of in accordance with Local, State, and Federal regulations.

CAS = Chemical Abstract Service	PEL = OSHA Permissible Exposure Limit
NI = No relevant information available	TLV = ACGIH Threshold Limit Value
NA = Not applicable	NTP = National Toxicology Program
Trade Secret = Claimed as allowed under 29 CFR 1910.1200	IARC = Int'l Agency for Research on Cancer

2557	ENSTRIP® N-190B	8/24/87

VIII. REACTIVITY DATA

X	Stable	CONDITIONS TO AVOID: Stable under normal conditions. See Incompatibility information.
	Unstable	
INCOMPATABILITY (Materials to avoid): Oxidizers, cyanides, alkalis.		
HAZARDOUS DECOMPOSITION PRODUCTS: Toxic oxides of nitrogen and carbon.		

HAZARDOUS POLYMERIZATION		May occur	CONDITIONS TO AVOID: NA
	X	Will not occur	

IX. ADDITIONAL INFORMATION

FREDERICK GUMM CHEMICAL COMPANY, INC.
538 Forest Street • Kearny, NJ 07032
800-223-GUMM • In NJ. 201-991-4171

Over 1200 metal finishing chemicals for surface preparation, plating, aluminum finishing, post finishing, and mass finishing.

TECHNICAL BULLETIN

CLEPO 204

For Stripping Nickel Without the Use of Cyanide

CLEPO 204 consists of two materials - CLEPO 204-T, a yellow powder, and CLEPO 204-N, a clear liquid. When made up and used as directed, the resulting solution will effectively strip nickel from copper brass and steel without the use of cyanides. It has also proven effective on electroless nickel which has not been aged or heat treated.

OPERATING CONDITIONS:

CONCENTRATION:

The stripping solution is prepared using the following proportions for 100 gallons (380 liters).

1. Dissolve 33 gal. (125 lit.) CLEPO 204-N in 67 gal (255 lit.) water.
2. Add 50 lb. (23 kilograms) CLEPO 204-T and stir until completely dissolved.

TEMPERATURE:

140-180 deg F. (60-80 deg C).

TIME:

Stripping time will vary, depending upon the type of nickel and its thickness.

As CLEPO 204 solutions are used and the concentration of nickel salts builds up, the stripping rate will decrease. The solution may be reactivated by the addition of 2 oz/gal (15 g/l) of CLEPO 204-T. When the total concentration of CLEPO 204-T has reached 12 oz/gal (90 g/l) and the stripping rate has slowed, the solution should be dumped and a new one prepared.

A certain amount of non-adherent smut will appear on the surface of the work. This will often disappear upon longer immersion in the stripping solution or will be easily removed in a subsequent rinse or cleaning cycle. A cyanide dip should not be necessary for smut removal if the work is given the proper immersion time in the CLEPO 204 solution to insure complete stripping.

Certain types of high sulfur bright nickel will produce a heavier smut than others. Running the bath within the recommended temperature range is very important, since low temperatures may result in the formation of smuts which are difficult to remove without a cyanide dip.

CHEMICAL PROFILE

pH of Working Solution	10.0-10.5
Phosphate Free	Yes
Effect of Water Hardness	None
Biodegradable	Yes

When stripping nickel from brass, the work should be removed from the stripping solution as soon as stripping is complete. With extended immersion times, even the inhibiting action of CLEPO 204 cannot always prevent some etching of the base metal. Always run CLEPO 204 solutions at the recommended concentrations and temperatures to insure minimum immersion times. Do not use severely depleted CLEPO 204 solutions for stripping brass since the longer stripping time required may result in some etching of the areas which strip first.

EQUIPMENT SELECTION

Mild steel tanks, mild steel or stainless steel heating coils

PHYSICAL CHARACTERISTICS

Physical Appearance	CLEPO 204-T - yellow powder CLEPO 204-N - clear liquid
Flash Point	None
Maximum Solubility	12 oz/gal.
Foaming Tendency	Low

CAUTION

CLEPO 204-N liquid is a moderately alkaline liquid and should be kept from contacting skin or eyes. Avoid inhalation of the fumes. In the event of contact with the skin, flush thoroughly with water. For eyes, flush thoroughly with water and get medical attention. Follow same precautions for use solutions.

WASTE DISPOSAL INFORMATION

CLEPO 204 solutions may be discarded by neutralizing the alkaline content in accordance with locally acceptable standards for effluent pH. Removal of metal sludge may be necessary due to local restrictions. CLEPO 204-T and CLEPO 204-N contain no chromates, cyanides, fluorides, phosphates, silicates, or phenolic compounds.

The information presented herein was prepared by technically knowledgeable personnel, and to the best of our knowledge is true and accurate. It is not intended to be all-inclusive, and the manner and conditions of use and handling may involve other or additional considerations.

Rev. 12/87

MATERIAL SAFETY DATA SHEET

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SECTION 1 - IDENTIFICATION DATA

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FREDERICK GUMM CHEMICAL COMPANY, INC.
538 Forest Street, Kearny, NJ 07032

Emergency Telephone Numbers:
8:00 AM - 5:00 PM.EST
(201) 991-4174
24 Hrs: (313) 644-5626

CLEPO 204-N

Effective Date:
11-19-86

D.O.T. HAZARD CLASS	- Corrosive Liquid NOS
CHEMICAL FAMILY	- Alkyl amine
CHEMICAL NAME/SYNONYMS	- CLEPO 204-N
FORMULA	- Mixture
MSDS REVIEWED BY	- Peter K. Dietrich, V.P. Quality & Regulatory Affairs

==

SECTION 2 - PHYSICAL DATA

==

BOILING POINT (Deg F)	- Approximately 212 degrees F
VAPOR PRESSURE (mm Hg)	- NA
VAPOR DENSITY (air=1)	- NA
SOLUBILITY IN WATER	- Complete
SPECIFIC GRAVITY (H2O=1)	- .983
VOLATILE BY VOLUME	- 99%
EVAPORATION RATE (H2O=1)	- 1

APPEARANCE & ODOR:
Brownish liquid

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SECTION 3 - FIRE AND EXPLOSION DATA

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FLASH POINT - None

EXTINGUISHING MEDIA:
This product is not combustible.

SPECIAL FIRE FIGHTING PROCEDURES:
Protective clothing and self-contained breathing apparatus should be worn by firefighters in areas where product is stored. Water spray, foam, dry chemical, or carbon dioxide may be used in areas where product is stored.

UNUSUAL FIRE AND EXPLOSION HAZARDS:
Will react with some metals, i.e. aluminum, tin and zinc, to release flammable hydrogen gas.

NFPA HAZARD CLASSIFICATION:

Health	(Blue)	- 3
Flammability	(Red)	- 0
Reactivity	(Yellow)	- 1

DEGREE OF HAZARD

4=Extreme
3=High
2=Moderate
1=Slight
0=Insignificant

==

SECTION 4 - REACTIVITY DATA

STABILITY: Stable
CONDITIONS TO AVOID: NA

INCOMPATIBILITY:
Strong acids.

HAZARDOUS DECOMPOSITION PRODUCTS:
None

HAZARDOUS POLYMERIZATION: Will not occur
CONDITIONS TO AVOID: NA

SECTION 5 - HAZARDOUS COMPONENTS

PAINTS, PRESERVATIVES, AND SOLVENTS:
NA
ALLOYS AND METALLIC COATINGS:
NA

HAZARDOUS COMPONENTS	CAS NUMBER	TLV	PEL	LD50	% W/W
#1,3-Diethylthiourea	105-55-5	NF	NF	316	0.50
Ethylenediamine	107-15-3	10	25	1160	33.0

TLV = Mg/M3 - PEL = Mg/M3 - LD50 = oral, rat, Mg/Kg - NF = None Found

- The indicated material, if any, is listed as a carginogen or potential carginogen by one or more of the following: National Toxicology Program, I.A.R.C. Monographs, OSHA.

** - The indicated material, if any, does not have an estabished TLV, but does appear on one or more of the following states hazardous substance lists: Connecticut, Illinois, Michigan, Maine, Massachusetts, Minnesota, New Hampshire, New Jersey, New York, Oregon, Rhode Island, West Virginia, and Wisconsin, and is present in this product in amounts greater than 1%.

SECTION 6 - SPILL, LEAK, AND DISPOSAL PROCEDURES

SPILL & LEAK PROCEDURES:
Liquids should be contained and absorbed with a suitable absorbent, or flushed to the waste treatment area. Flush area with plenty of water. Avoid all personal contact.

WASTE DISPOSAL METHODS:
Waste solution should not be discharged into sewers or streams. Solution should first be neutralized to a locally acceptable pH, and then well diluted with water. Depending on usage and locality, may also require precipitation and filtration of heavy metals. Otherwise, contact local waste disposal contractor.

SECTION 7 - HEALTH HAZARD DATA

ROUTES OF EXPOSURE

INHALATION: Airborne concentrations of dust, mist, or spray of this product may cause damage to the upper respiratory tract and even to the lung tissue which could produce chemical pneumonia depending upon severity of exposure.

SKIN CONTACT: This product is corrosive to tissues contacted and may cause burns.

SKIN ABSORPTION: See SKIN CONTACT above.

EYE CONTACT: This product is destructive to eye tissues on contact. May cause permanent eye damage.

INGESTION: This product, if swallowed, will be corrosive to the mouth, throat, and stomach.

EFFECTS OF OVEREXPOSURE

ACUTE: Corrosive to all body tissues with which it comes in contact.

CHRONIC: The chronic local effect may consist of multiple areas of superficial destruction of the skin or of primary irratant dermatitis. Similarly, innalation of dust, spray, or mist may result in vary degrees of irritation or damage to the respiratory tract tissues.

EMERGENCY AND FIRST AID PROCEDURES

EYES: IMMEDIATELTY flush eyes with large amounts of water for at least 15 minutes, holding lids apart to ensure flushing of the entire surface. Washing eyes within 1 minute is essential to achieve maximum effectiveness. Seek medical attention immediately.

SKIN: Immediately wash contaminated areas with plenty of water for 15 minutes. Remove contaminated clothing and footwear, and wash clothing before reuse. Discard any clothing that can not be decontaminated. Seek medical attention immediately.

INHALATION: Get person out of contaminated area to fresh air. If breathing has stopped, resuscitate and administer oxygen if readily available. Seek medical attention immediately.

INGESTION: NEVER give anything by mouth to an unconscious person. If swallowed, DO NOT INDUCE VOMITING. If vomiting occurs spontaneously, keep airway clear. Seek medical attention immediately.

SECTION 8 - SPECIAL HANDLING PROCEDURES

RESPIRATORY: Respiration protection is not required under normal use. Use NIOSH/MHSA approved respirator where dust, mist, or spray may be generated above the TLV limit.

==
SECTION 8 - SPECIAL HANDLING PROCEDURES continued
==

VENTILATION: Use adequate local exhaust ventilation where dust, mist, or spray may be generated, to maintain level below the TLV limit.

GLOVES: Impervious gloves should be worn(ex. rubber or neoprene).

EYES: Chemical safety goggles and/or face shield.

OTHER: Chemically resistant shoes and apron. Safety showers and eyewash facilities should be acessible. All contaminated clothing should be washed with soap and water, and dried before reuse.

==
SECTION 9 - SPECIAL PRECAUTIONS
==

HANDLING AND STORAGE PRECAUTIONS::
DO NOT STORE WITH STRONG ACIDS OR OXIDIZERS. AVOID CONTACT WITH SKIN AND EYES. DRUM MUST NOT BE USED FOR ANY OTHER PURPOSE.

OTHER PRECAUTIONS:
Keep container tightly closed when not in use. Wash thoroughly after handling. Containers, even those that have been emptied, will retain product residue and vapors. Always obey hazard warnings and handle empty containers as if they were full. Containers must not be used for any other purpose.

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MATERIAL SAFETY DATA SHEET

SECTION 1 - IDENTIFICATION DATA

FREDERICK GUMM CHEMICAL COMPANY, INC.
538 Forest Street, Kearny, NJ 07032

Emergency Telephone Numbers:
8:00 AM. - 5:00 PM EST
(201) 991-4174
24 Hrs: (313) 644-5626

CLEPO 204-T

Effective Date:
05-18-88

D.O.T. HAZARD CLASS - Chemical NOS
CHEMICAL FAMILY - AROMATIC NITRO
CHEMICAL NAME/SYNONYMS - CLEPO 204-T
FORMULA - Mixture
MSDS REVIEWED BY - Peter K. Dietrich, V.P. Quality & Regulatory Affairs

SECTION 2 - PHYSICAL DATA

BOILING POINT (Deg F) - NA
VAPOR PRESSURE (mm Hg) - NA
VAPOR DENSITY (air=1) - NA
SOLUBILITY IN WATER - INSOLUBLE
SPECIFIC GRAVITY (H2O=1) - NA
VOLATILE BY VOLUME - NA
EVAPORATION RATE (H2O=1) - NA

APPEARANCE & ODOR:
Off-white crystalline powder

SECTION 3 - FIRE AND EXPLOSION DATA

FLASH POINT - NONE

EXTINGUISHING MEDIA:
Water, watger fog, CO2 , dry chemical. foam.

SPECIAL FIRE FIGHTING PROCEDURES:
Protective clothing and self-contained breathing apparatus should be worn by firefighters in areas where product is stored.

UNUSUAL FIRE AND EXPLOSION HAZARDS:
Thermal decomposition will result in the release of potentially dangerous NOx vapors.

NFPA HAZARD CLASSIFICATION:

Health (Blue) - 3
Flammability (Red) - 1
Reactivity (Yellow) - 1

DEGREE OF HAZARD

4=Extreme
3=High
2=Moderate
1=Slight
0=Insignficant

SECTION 4 - REACTIVITY DATA

STABILITY: Stable
CONDITIONS TO AVOID: Avoid open flames or other high temperature sources which might cause thermal decomposition.

INCOMPATIBILITY:
Base. Gringing or mixing the material in the presence of dry alkali(i.e sodium or potassium hydroxide) may cause autoignition.

HAZARDOUS DECOMPOSITION PRODUCTS:
Thermal decomposition will result in a release of NOx vapors.

HAZARDOUS POLYMERIZATION: Will not occur
CONDITIONS TO AVOID: NA

SECTION 5 - HAZARDOUS COMPONENTS

PAINTS, PRESERVATIVES, AND SOLVENTS:
NA
ALLOYS AND METALLIC COATINGS:
NA

HAZARDOUS COMPONENTS	CAS NUMBER	TLV	PEL	LD50	% W/
NONE					

TLV = Mg/M3 - PEL = Mg/M3 - LD50 = oral, rat, Mg/Kg - NF = None Foun

- The indicated material, if any, is listed as a carginogen or potential carginogen by one or more of the following: National Toxicology Program, I.A.R.C. Monographs, OSHA.

** - The indicated material, if any, does not have an estabished TLV, but does appear on one or more of the following states hazardous substance lists Connecticut, Illinois, Michigan, Maine, Massachusetts, Minnesota, New Hampshire, New Jersey, New York, Oregon, Rhode Island, West Virginia, and Wisconsin, and is present in this product in amounts greater than 1%.

SECTION 6 - SPILL, LEAK, AND DISPOSAL PROCEDURES

SPILL & LEAK PROCEDURES:
Spilled material may be shoveled up, and stored in closed containers for possible normal use or proper disposal. Flush area with plenty of water.

WASTE DISPOSAL METHODS:
Waste should not be discharged directly into sewers or streams.
Neutralize to a locally acceptable pH, depending on usage and locality.
May also require precipitation and filtration of heavy metals.

SECTION 7 - HEALTH HAZARD DATA

ROUTES OF EXPOSURE

INHALATION: Coughing, sneezing, or other symptoms of upper respiratory tract irritation may occur. Severe exposure may result in lung tissue damage.

SKIN CONTACT: Dry product can be a skin irritant.

SKIN ABSORPTION: NA

EYE CONTACT: Dry product can cause tissue destruction and permanent eye damage if not treated immediately.

INGESTION: Dry product irritates mucous membranes of the mouth, throat, esophagus, and stomach.

EFFECTS OF OVEREXPOSURE

ACUTE: Irritates the mucous membranes of the respiratory tract, mouth, throat, esophagus, and stomach. Can also cause permanent eye injury.

CHRONIC: Data not available.

EMERGENCY AND FIRST AID PROCEDURES

EYES: IMMEDIATELY flush eyes with large amounts of water for at least 15 minutes holding lids apart to ensure flushing of the entire surface. Washing eyes within one minute is essential to achieve maximum effectiveness. Seek medical attention immediately.

SKIN: Wash with plenty of water for 15 minutes. Remove contaminated clothing and footwear, and wash clothing before reuse. Discard any piece of clothing or footwear that can not be decontaminated. Seek medical attention if symptoms are present.

INHALATION: Get person out of contaminated area to fresh air.

INGESTION: NEVER give anything by mouth to an unconscious person. If swallowed, DO NOT INDUCE VOMITING. Give large quantities of water. If vomiting occurs spontaneously, keep airway clear. Seek medical attention immediately.

SECTION 8 - SPECIAL HANDLING PROCEDURES

RESPIRATORY: Respiration protection is not required under normal use. Use NIOSH/MSHA approved respirator where dust, mist, or spray may be generated.

VENTILATION: Use adequate local exhaust ventilation where dust, mist, or spray may be generated.

SECTION 8 - SPECIAL HANDLING PROCEDURES continued

GLOVES: Imoervious gloves should be worn (ex. rubber or neoprene).

EYES: Chemical safety goggles and/or face shield.

OTHER: Chemically resistant shoes and apron. Safety showers and eyewash facilities shoulc be accessible. Wash contaminated clothing with soap and water, and dry before reuse.

SECTION 9 - SPECIAL PRECAUTIONS

HANDLING AND STORAGE PRECAUTIONS::
Avoid contact with skin and eyes. Wash thoroughly after handling. Store in a cool, dry area in a closed container.

OTHER PRECAUTIONS:
Keep container tightly closed when not in use. Wash thoroughly after handling. Containers, even those that have been emptied, will retain product residue and vapors. Always obey hazard warnings and handle empty containers as if they were full. Containers must not be used for any other purpose.

TM

Data Sheet

McGean-Rohco, Inc.
ROHCO DIVISION

Rostrip® Electrolytic Stripper 999-SP

General Description

A powdered electrolytic stripper to remove copper, nickel, and other metals from steel parts when electrolytic current is used. This product does not contain cyanides or amines which cause problems in disposal.

Advantages

1. Strips chrome and nickel in the same solution.
2. Operates at room temperature.
3. Low carbon steel can be replated without polishing.
4. Easy to operate.
5. No objectionable odors are generated even at high pH.

Operating Conditions

1. 1-2 pounds per gallon of water (120-240 g/l).
2. pH range 12-14.
3. Use stainless steel cathodes.
4. Operate at 80-100°F, (26-38°C) (Higher temperatures will result in pitting. Use steel cooling coils to reduce temperature.
5. Current density should be at least 100 ASF. (10 amp per sq. dm).
6. A 6-9 volt rectifier is required.

Tank

Steel - Depth should be 1/3 deeper than the longest rack to allow sludge to settle.

Current

Reverse - (Part is anode).

Rack

Mild steel or 300 series stainless steel tips. Do not use copper tips. Be sure rack spline and copper area are completely covered by rack coating. Copper rack hooks should be plastisol covered well above solution level.

McGEAN-ROHCO, INC. - 2910 HARVARD AVE. - P. O. BOX 09087 - CLEVELAND, OHIO 44109 (216) 441-4900, TELEX 24-1124

BEFORE USING ANY OF THESE PRODUCTS, PLEASE OBTAIN A MSDS SHEET FROM THE MANUFACTURER AND BECOME COMPLETELY FAMILIAR WITH THE SAFETY HAZARD INFORMATION

Control

1. Pipette 2 ml sample of solution into a 250 ml Erlenmeyer flask, and add 50 mls of distilled water.
2. Pipette 25 mls of 0.1N ceric ammonium sulfate into flask then add 10 mls of 50% hydrochloric acid.
3. Add 1-2 drops ferroin indicator.
4. Back titrate with ferrous ammonium sulfate 0.1 Normal until solution changes from green to rose.

Calculation

25 minus mls of 0.1N ferrous times 2.56 equals oz/gallon Rostrip Electrolytic Stripper 999-SP.

Oz/gallon times 7.5 equals g/l.

Desludging

Allow sludge to settle in a separate tank. Decant off clear liquid and return to stripper tank. Sludge may be concentrated by use of plate and frame filter.

Handling Considerations

Rostrip Electrolytic Stripper 999-SP is a strong oxidizer, which contains nitrates. Store away from cyanide, combustible materials, organics, reducing agents, and acids. Store in cool dry area.

DANGER: This product contains caustic which is corrosive. When handling this product, do not breathe dust which is very irritating to the upper respiratory tract. Avoid contact with skin and eyes. Wear clean clothing, chemical goggles, rubber gloves, apron, boots, gauntlets and full face shield.

While making solutions, add product slowly to surface of solution with agitation to avoid splatter or violent eruptions. Do not add to hot solution. Close container when not in use. Use adequate ventilation. Avoid dust or mist. Do not take internally.

First Aid

If skin and/or eyes are contacted with chemical, immediately flush affected area with clean water for 15 minutes. For skin burn and eye contact, get medical attention.

McGean-Rohco, Inc.

1250 Terminal Tower, Cleveland, Ohio 44113, 216/621 6425

MATERIAL SAFETY DATA SHEET

Product Name: Rostrip Electrolytic Stripper 999-SP		Emergency Phone No (313) 872-1800
Plant Address: 38521 Schoolcraft Avenue, Livonia, MI 48150		Chemtrec Phone No. 800/424-9300
Prepared By: M. Arthur Detrisac	Issue Date: 9-17-88	Revised Date:

INGREDIENTS AND HAZARDOUS COMPONENTS

Material	%	TLV	C.A.S. #	Suspect Carcinogen
Caustic Soda	0.9	2mg/M³	1310-72-2	No

PHYSICAL DATA

Boiling Point: NA	Freezing Point: NA	Specific Gravity: NA	pH: 10% solution 14.0
Vapor Pressure at 20° C: NA	Vapor Density (Air = 1): NA	% Volatiles by Volume: NA	Odor: None
Evaporation Rate (Butyl Acetate = 1) NA		Solubility in Water: Appreciable	
Appearance and Form: Blue Powder Granules.			

FIRE AND EXPLOSION HAZARD DATA

Flash Point: NA	Flammable Limits in Air: NA Upper: % By Volume Lower:
Test Method: NA	
Extinguishing Media: NA	
Special Fire Fighting Procedures: NA	
Unusual Fire and Explosion Hazards: May react with amphoteric metals such as aluminum. Can generate hydrogen which is flammable or explosive.	
DOT Classification: Oxidizer, Corrosive Solid, NOS NA 9194	Note: UK = Unknown NA = Not Applicable

* AFTER 5:00PM CALL EITHER 559-2775 OR 455-6587

HEALTH HAZARD DATA

Effects of Overexposure and Primary Entries to Body:	Corrosive to eyes, skin, and human tissue.
Emergency and First Aid Procedures:	Immediately flush with plenty of water for at least 15 minutes. If medical attention has not been obtained, continue flushing. <u>Ingestion</u>: Give milk and plenty of water. Call physician immediately. Do not induce vomiting.

REACTIVITY DATA

[X] Stable [ ] Unstable — Conditions to Avoid:	Do not contact with acids.
Incompatability — Materials to Avoid:	Exothermic heat of solution. Reacts with strong acid.
Hazardous Decomposition Products:	If acidified will give off nitrous oxide.
Hazardous Polymerization:	[ ] May Occur [X] Will Not Occur

SPILL OR LEAK PROCEDURES

Spills:	Sweep up and dispose as caustic soda in a steel container.
Waste Disposal Methods:	Dilute with water. Neutralize with dilute acid. DISPOSER MUST COMPLY WITH FEDERAL, STATE, AND LOCAL DISPOSAL LAWS.

SPECIAL PROTECTION INFORMATION

Respirator: Use dust mask.		
Ventilation: Local Exhaust-Normal Rate.		
Gloves: Neoprene	Eye and Face: Face Mask or Chemical Goggles	Other: Rubber Apron and Boots.

Handling and Storage: Store in dry area away from amphoteric metals, e.g., Aluminum or zinc. Also, store away from strong acids. Do not add to hot water. The chemical may boil over or spatter while adding to water. Add slowly with constant agitation to prevent spatter, boil over, and ensure complete solublizing. Contains sodium nitrite which will liberate nitrous oxide fumes when made acid.

PD-048 – Rev 2-85

M&T CHEMICALS INC.
GENERAL OFFICES
Rahway, New Jersey 07065-0970
(201) 499-0200

PRELIMINARY TECHNICAL INFORMATION

NI-PLEX 100 STRIP
FOR REMOVING NICKEL FROM STEEL

Ni-plex 100 Nickel Strip is a revolutionary concept in nickel stripping. It was formulated with the problems of the plater in mind.

Ni-plex 100 Nickel Strip will strip electrodeposited nickel and electroless nickel from steel with no measurable corrosion of the base metal.

ADVANTAGES

1. No corrosive liquids involved. Ni-plex 100 Nickel Strip is a mildly alkaline powder.
2. Much easier disposal when the bath's capacity has been reached.
3. Contains no dangerous or highly corrosive chemicals such as cyanide or harsh amines.
4. No more cyanide or chromic acid posts dips to remove smut.
5. Fast stripping rate.
6. Stable for long periods at operating temperature.

PREPARATION OF STANDARD NI-PLEX 100 NICKEL STRIP

Fill the stripping tank half full of 120-150°F water. Add 2½ lbs. of Ni-plex 100 for each gallon of the tank's working capacity.

Complete filling the tank with water and stir while heating to the operating temperature of 120-150°F. After dissolving the powder into solution you may check the pH of the bath. If the pH is below 8.5 add Soda Ash to bring the pH into the range of 8.5-10.5.

Caution: May cause skin or eye irritation. Avoid contact with skin, eyes and clothing. Avoid breathing dust. Use with adequate ventilation. In case of contact, flush skin or eyes with plenty of water; for eyes, get medical attention.

cont'd

OPERATION OF STANDARD BATH

Temperature: A working temperature of 120-150°F is recommended. The bath will operate in a wide range from room temperature to boiling, but will not strip as efficiently outside the recommended range. Bath should be cooled to room temperature when not in use to prolong life.

Agitation: Very gentle air, pumped solution or mechanical agitation is essential to prevent stratification of the bath.

Additions: Additions of Ni-plex 100 in the ratio of the original bath make-up can be made up to saturation, however, each user should evaluate the economics of making additions versus the cost of discarding and make up a new bath.

Part Preparation: Parts to be stripped should be reasonably clean and should have all chromium removed by any one of several state-of-the-art methods:

Immerse in 50% hydrochloric acid at room temperature
Immerse in an alkaline cleaner with reverse current

Rinse parts well and immerse in Ni-plex 100 Nickel Strip solution. Parts should be suspended in the solution, not touching the bottom or sides of the tank nor the heating coils, and should be slightly spaced to allow the solution to circulate between, thus avoiding point-contact problems. For the most economical operation, we recommend that the user strip as many parts as possible at one time, filling the tank to capacity.

Hot water should be added periodically to bring the solution back to the original level. If adding water at the end of the stripping operation, use cold water to assist in quickly cooling the bath and prolonging the life of the bath.

Post Treatment: The black smut that remains on the article after stripping has plagued platers since the introduction of non-cyanide nickel strips. Ni-plex 100 Nickel Strip has solved this problem by the use of reverse current at 6 or more volts while the article is in the strip solution (pat. pend.). Incomplete stripping can be quickly discovered and returned to the strip tank with no bad effects on the base metal. We have found that, when stripping electroless nickel in a new bath up to half-life, no smut remains on the parts if they are allowed to remain in the bath for 1-2 hours after stripping. This process, however, is not as effective after the bath has passed its half-life.

When there is a copper strike under the nickel plate, some of the copper will be removed during the smut removal operation. Check your parts more often during the de-smutting operation to minimize copper removal. When removing smut from copper or copper-plated articles, a separate cold smut removal tank is highly recommended, since the copper will contaminate your stripping bath and will reduce its' life. A cost savings can be gained by using 25-50% spent Ni-plex 100 Nickel Strip with the remainder being fresh Ni-plex 100 solution at ½ concentration of 3/4 lb/gal.

cont'd.

EQUIPMENT REQUIRED

Tanks may be mild steel, polypropylene or any lined tank that will survive the operational temperature.

Agitation of solution is essential to prevent stratification of bath. User may employ mild air agitation, pumped solution, or mechanical agitation.

Heaters are required to maintain a recommended temperature of 120-150°F during stripping operation.

STRIPPING RATES

A new Ni-plex 100 Strip solution using the recommended amount of Ni-plex 100 Strip and the recommended temperature of 120-150°F should strip electrolytic nickel at a rate of 1 to 2 mils per hour and should dissolve approximately 3 to 4 ounces per gallon of solution. Rate of dissolution of electroless nickel plate is dependent upon the phosphorous content of the plate.

To prolong bath life, let solution cool to room temperature after use. All chemical nickel strips work best (i.e. strip the most nickel per gallon of original solution) when they are used up quickly. A stripping bath that is used lightly and kept very hot may strip only 1/4 to 1/2 the nickel of an identical bath which is used quickly.

ANALYTICAL PROCEDURES

1. Pipet a 1 ml. sample into a 250 ml. Erlenmeyer flask.
2. With a graduate, add 50 ml. of distilled water, 10 ml. of ammonia buffer (1 molar ammonium chloride and ammonium hydroxide) and one tablet of murexide indicator (0.4 mg. tableted with potassium chloride). Swirl to dissolve.
3. Fill a 50 ml. buret with 0.1M disodium EDTA and titrate the solution until the color changes from yellowish-green to deep purple.
4. Read the buret. The ml. of EDTA used, multiplied by 0.78, gives the ounces of nickel metal per gallon of plating solution.

DISPOSAL

Disposal of the spent stripping solution is the area in which Ni-plex 100 Strip excels! Ni-plex 100 Strip contains no chemicals that would be considered hazardous or would be unacceptable in a public treatment works!! It is completely bio-degradable after removal of the nickel!!

Following are two methods of nickel removal:

1. Nickel hydroxide precipitation through pH adjustment.
2. Nickel oxide precipitation through treatment with sodium hypochlorite.

cont'd.

DISPOSAL (cont'd.)

Method #1 can be better accomplished if the spent bath is diluted as much as possible after adjusting the pH to 11.5-12.5.

Method #2 gives much less precipitate, however, the solution must stay in the alkaline pH range and should be filtered as soon as possible to prevent rehydration of the oxide to nickel hydroxide.

TOXICOLOGY - HYGIENE

Ni-plex 100 Strip can cause irritation and burns to the eyes and skin. Avoid eye and skin contact. The dust is irritating to the respiratory system and should not be inhaled. The material is toxic and must not be swallowed.

SUGGESTED FIRST AID

In the event of eye contact, wash the eyes thoroughly by means of a continuously flowing stream of water directed into the eyes for at least 15 minutes. A physician should then be consulted.

In case of skin contact, drench the exposed area with water for 10 to 15 minutes. Launder contaminated clothing before re-use.

Note: "Material Safety Data Sheet" on this product is available on request from the Safety and Environmental Affairs Department of M&T Chemicals Inc., Rahway, New Jersey 07065.

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4/2/86

MATERIAL SAFETY
DATA SHEET

M&T*. CHEMICALS INC.
PO BOX 1104
RAHWAY, NJ 07065

EMERGENCY TELEPHONE NUMBERS
8:30 AM - 4:30 PM
(201) 499-2403
AFTER HOURS
(201) 499-2445

NAME USED ON LABEL: NIPLEX 100
CHEMICAL NAME (IF SINGLE SUBSTANCE): N/A
CHEMICAL FAMILY: N/A
FORMULA: PROPRIETARY

INGREDIENTS

IDENTITY	CAS NO.	%	TLV
SODIUM CARBONATE	139-02-6	>50	NOT ESTABLISHED
ORGANIC COMPOUND	(SEE MISC.)	<50	NOT ESTABLISHED

PHYSICAL DATA

BOILING POINT: NONE
SPECIFIC GRAVITY: 8.3 LBS/GAL
VAPOR DENSITY: N/A
% VOLATILES: N/A
MOLECULAR WEIGHT: N/A
APPEARANCE AND ODOR: WHITE TO YELOW GRANULES

FREEZING POINT: N/A
VAPOR PRESSURE @ 20 C: N/A
SOLUBILITY IN WATER: COMPLETE
EVAPORATION RATE: N/A
OTHER:

FIRE AND EXPLOSION DATA

FLASH POINT (TEST METHOD)	AUTOIGNITION TEMPERATURE	FLAMMABLE LTS.
N/A	N/A	LEL= UEL=

EXTINGUISHING MEDIA: WATER SPRAY

SPECIAL FIRE FIGHTING PROCEDURES: AVOID EYE AND SKIN CONTACT

UNUSUAL FIRE AND EXPLOSION HAZARDS: NONE

MATERIAL SAFETY
DATA SHEET

MCT* CHEMICALS INC.
RAHWAY, NJ 07065

NAME USED ON LABEL: NIPLEX 100

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ENVIRONMENTAL INFORMATION

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SPILL RESPONSE: PRODUCT IS BIODEGRADABLE. LARGE QUANTITIES MAY POSE AN AQUATIC HAZARD. IN CASE OF SPILL, CAREFULLY SWEEP UP MATERIAL AND TRANSFER TO A SUITABLE CONTAINER (STEEL DRUM) FOR DISPOSAL. AVOID CREATING A DUSTY ATMOSPHERE. AFTER SWEEPING, FLUSH AREA WHERE SPILL OCCURRED WITH WATER. DILUTE WATER RESIDUE MIXTURE MAY BE FLUSHED TO SEWER WITH LARGE AMOUNTS OF WATER.

RECOMMENDED DISPOSAL: DISPOSE OF MATERIAL AS SOLID WASTE. SMALL QUANTITIES MAY BE FLUSHED TO SEWER WITH LARGE AMOUNTS OF WATER. DISCHARGE TO A PUBLIC SEWERAGE AUTHORITY SHOULD COINCIDE WITH ALL APPLICABLE LOCAL PERMITS AND NOTIFICATION REQUIREMENTS. FOLLOW ALL CHEMICAL POLLUTION CONTROL REGULATIONS.

EPA HAZ. WASTE DESIGNATION (FOR VIRGIN PRODUCT): NONE

OTHER:

****

HEALTH HAZARD DATA

****

EYE CONTACT: MAY CAUSE MINOR IRRITATION.

SKIN CONTACT: MAY CAUSE MINOR IRRITATION UPON CONTACT.

INHALATION: DUST MAY CAUSE IRRTTATION TO THE RESPIRATORY TRACT.

CHRONIC TOXICITY: NO KNOWN EFFECTS

SUGGESTED FIRST AID:

EYES: IN CASE OF CONTACT, IMMEDIATELY FLUSH EYES WITH FLOWING WATER FOR AT LEAST 15 MINUTES. GET MEDICAL ATTENTION.

SKIN: WASH WITH MILD SOAP AND WATER. IF IRRITATION DEVELOPS GET MEDICAL ATTENTION.

INHALATION: MOVE EXPOSED INDIVIDUAL TO FRESH AIR. CALL A PHYSICIAN.

INGESTION: NEVER GIVE FLUIDS OR INDUCE VOMITING IF PATIENT IS UNCONSCIOUS OR HAVING CONVULSIONS. GET MEDICAL ATTENTION.

MATERIAL SAFETY
DATA SHEET

MET* CHEMICALS INC.
RAHWAY, NJ 07065

NAME USED ON LABEL: NIPLEX 100

REACTIVITY DATA

STABILITY: STABLE
CONDITIONS TO AVOID: AVOID TEMPERATURE OVER 500 F

INCOMPATABILITY (MATERIALS TO AVOID): OXIDIZING AGENTS

HAZARDOUS POLYMERIZATION: WILL NOT OCCUR
CONDITIONS TO AVOID: THEPERATURE EXCEEDING 500 F, OXIDIZING AGENTS

HAZARDOUS DECOMPOSITION PRODUCTS: NONE KNOWN

SPECIAL PROTECTION INFORMATION

VENTILATION: LOCAL EXHAUST IS RECOMMENDED.
MECHANICAL (GENERAL) IS REQUIRED.
RESPIRATORY PROTECTION: USE NIOSH APPROVED DUST MASK IF VENTILATION IS INADEQUATE.

EYE AND FACE PROTECTION: CHEMICAL WORKERS GLASSES DO NOT WEAR LENSES.
OTHER CLOTHING AND EQUIPMENT: GENERAL PURPOSE GLOVES.

SPECIAL PRECAUTIONS

PRECAUTIONARY LABEL INFORMATION: CAUTION! MAY CAUSE IRRITATION. AVOID CONTACT WITH EYES, SKIN, AND CLOTHING. WASH THOROUGHLY AFTER HANDLING.

STORAGE AND HANDLING: NORMAL WAREHOUSE STORAGE.

MATERIAL SAFETY
DATA SHEET

M&T* CHEMICALS INC.
RAHWAY, NJ 07065

NAME USED ON LABEL: NIPLEX 100

****

TRANSPORTATION

****

DEPARTMENT OF TRANSPORTATION (DOT)
- DOT PROPER SHIPPING NAME: NONE REQUIRED
- DOT HAZARD CLASS: NONE REQUIRED
- DOT LABEL: NONE REQUIRED
- DOT ID #: NONE REQUIRED

****

MISCELLANEOUS

****

ORGANIC COMPOUND: NON-HAZARDOUS ACCORDING TO THE CRITERIA OF PARAGRAPH (D) OF THE OSHA HAZARD COMMUNICATION STANDARD. ALL PERTINENT INFORMATION CONCERNING THE PROPERTIES, SAFE HANDLING, AND HEALTH EFFECTS OF THE CHEMICAL(S) IS DISCLOSED OF THIS MSDS.

PREPARED BY SAFETY & ENVIRONMENTAL AFFAIRS   ISSUED: 10/23/86
SUPERSEDES: 02/28/86

B-9 NICKEL STRIPPER

For removal of Nickel from Steel

PERFORMANCE AND BATH LIFE

WHEN MIXED IN ACCORDANCE WITH SIMPLE DIRECTIONS AND OPERATED AT THE RECOMMENDED TEMPERATURE, A NEW SOLUTION OF B-9 NICKEL STRIPPERS SHOULD STRIP ELECTROLYTIC NICKEL AT THE RATE OF ONE TO TWO MILS PER HOUR AND SHOULD DISSOLVE 2½ - 6 OUNCES OF NICKEL PER GALLON OF SOLUTION.

THE STRIPPING RATE OF ELECTROLESS NICKEL DEPENDS ON THE PHOSPHORUS CONTENT OF THE PLATE. A PHOSPHORUS CONTENT NOT EXCEEDING 11% SHOULD DISSOLVE AT THE SAME APPROXIMATE RATE AS ELECTROLYTIC NICKEL PLATE.

INSTRUCTIONS ARE INCLUDED ON PAGE #4 FOR FAST, EFFICIENT REMOVAL OF HIGH PHOSPHORUS ELECTROLESS NICKEL.

FOR SUPERIOR REMOVAL OF NICKEL-IRON COSTINGS, A SPECIAL B-9 NICKEL-IRON STRIPPER IS AVAILABLE AND MIXING INSTRUCTIONS ARE INCLUDED ON PAGE #5.

FOR STRIPPING NICKEL FROM BRASS, COPPER, ZINC DIECAST, SILVER, AND GOLD SUBSTRATES, OUR B-929 IS AVAILABLE WITH A STRIPPING PERFORMANCE AT THE SAME FAST RATE AS OUR REGULAR B-9 NICKEL STRIPPER.

CHEMICAL NICKEL STRIPPERS REMOVE THE MOST NICKEL PER GALLON OF SOLUTION WHEN THEY ARE CORRECTLY MAINTAINED. A STRIPPING BATH THAT IS USED LIGHTLY AND KEPT HOT OVER A PROLONGED TIME PERIOD WILL STRIP LESS NICKEL THAN AN IDENTICAL BATH WHICH IS USED QUICKLY. TO PROLONG BATH LIFE, ALLOW ALL B-9 PRODUCTS TO COOL TO ROOM TEMPERATURE WHEN NOT IN USE.

TANKS AND EQUIPMENT

TANKS: TANKS MAY BE UNLINED STEEL, POLYPROPYLENE, BARRELS, OR ANY LINED TANK THAT WILL SURVIVE OPERATIONAL TEMPERATURE.

AGITATION: AGITATION OR CIRCULATION OF THE B-9 STRIPPER SOLUTION IS REQUIRED TO PREVENT STRATIFICATION OF THE BATH. MILD AIR, PUMPED OR STIRRED SOLUTION,MECHANICAL AGITATION OR TUMBLING ARE ALL ADEQUATE METHODS.

HEAT: SOLUTION HEATING IS REQUIRED TO MAINTAIN A RECOMMENDED TEMPERATURE OF 120°-150°F DURING THE STRIPPING OPERATION. TO PROLONG BATH LIFE, HEATING SHOULD BE DISCONTINUED IMMEDIATELY AFTER USE. NOTE: STEAM HEAT IS NOT RECOMMENDED BUT, IF USED, YOU MUST AGITATE THE BATH THOROUGHLY TO REDUCE BOILING OF THE BATH AT THE INTERFACE OF THE HEATER. IT IS RECOMMENDED THAT AGITATION BE DIRECTED AT, OR PLACED UNDER, THE STEAM COILS TO QUICKLY MOVE THE SOLUTION FROM THE HEATING COILS.

CONT......

REMOVING ELECTROLYTIC NICKEL FROM STEEL WITH B-9 NICKEL STRIPPER

THERE ARE TWO METHOD OF USAGE OF ALL B-9 PRODUCTS: THE BATCH METHOD AND THE ADDITION METHOD. THE BATCH METHOD IS OFTEN USED BY THOSE OPERATORS WHO WISH TO MAKE UP SMALLER BATHS AS NEEDED AND USE THEM TO COMPLETION, USUALLY REMOVING 2½ - 4 OUNCES OF NICKEL PER GALLON OF SOLUTION. THOSE OPERATORS USING LARGER TANKS WHO NEED TO ACHIEVE GREATER LIFE AND NICKEL CONCENTRATIONS MAY USE THE ADDITION METHOD.

MIXING INSTRUCTIONS - BATCH METHOD

1. FILL THE STRIPPING TANK HALF FULL OF 120^{0}-150^{0}F WATER.
2. ADD TWO AND ONE-HALF (2½) POUNDS OF B-9 NICKEL STRIPPER FOR EACH GALLON OF THE TANK'S WORKING CAPACITY.
3. COMPLETE FILLING THE TANK WITH WARM WATER AND STIR WHILE HEATING TO THE OPERATING TEMPERATURE OF 120^{0}-150^{0}F.
4. CHECK pH OF THE BATH. IT SHOULD BE 9.2 - 9.8. IF LOWER, RAISE THE pH BY SLOWLY ADDING SODA ASH WHILE STIRRING.
5. WHEN THE PROPER pH HAS BEEN ATTAINED, THE PROPER TEMPERATURE REACHED, AND THE POWDER DISSOLVED,THE STRIPPING BATH IS READY TO USE FOLLOW "BATH OPERATION PROCEDURES" OUTLINED BELOW.

MIXING INSTRUCTIONS- ADDITION METHOD

1. FILL STRIPPING TANK HALF FULL OF 120^{0}-150^{0}F WATER.
2. ADD ONE AND ONE-HALF (1½) POUNDS OF B-9 NICKEL STRIPPER FOR EACH GALLON OF THE TANK'S WORKING CAPACITY.
3. COMPLETE FILLING THE TANK WITH WARM WATER AND STIR WHILE HEATING TO THE OPERATING TEMPERATURE OF 120^{0}-150^{0}F.
4. CHECK THE pH OF THE BATH. IT SHOULD BE 9.2 - 9.8. IF LOWER, RAISE THE pH BY SLOWLY ADDING SODA ASH WHILE STIRRING.
5. WHEN THE PROPER pH HAS BEEN ATTAINED, THE PROPER TEMPERATURE REACHED, AND THE POWDER DISSOLVED, YOUR STRIPPING BATH IS READY TO USE.
6. AFTER COMPLETION OF EACH STRIPPING OPERATION, ANALYZE YOUR BATH FOR NICKEL CONTENT USING THE STANDARD MUREXIDE INDICATOR PROCEDURE. (PROCEDURE LISTED BELOW FOR YOUR CONVENIENCE) AFTER COMPLETING YOUR TITRATION PROCEDURE, YOU MAY BRING YOUR BATH BACK TO THE ORIGINAL OPERATING CONDITION BY ADDING .60 POUNDS OF B-9 PER GALLON OF TANK VOLUME PER OUNCE OF NICKEL IN SOLUTION.
7. AFTER STIRRING IN THE ADDITION, COOL TANK UNTIL NEXT USAGE. DO NOT COVER.

BATH OPERATION PROCEDURES

AFTER REMOVING ALL CHROMIUM, IMMERSE PARTS IN THE B-9 STRIPPER SOLUTION. RACKED PARTS SHOULD BE SUSPENDED IN SOLUTION, NOT TOUCHING THE BOTTOM OR SIDES OF THE TANK OR HEATING COILS. PARTS SHOULD BE SLIGHTLY SPACED TO ALLOW CIRCULATION OF STRIPPER SOLUTION AND AVOID POINT-CONTACT PROBLEMS. FOR THE MOST ECONOMICAL OPERATION, IT IS RECOMMENDED THAT THE OPERATOR STRIP AS MANY PARTS AS CAN POSSIBLY BE PUT IN THE TANK AT ONE TIME, FILLING IT TO ITS PART-HOLDING CAPACITY. PARTS CAN BE VERY SUCCESSFULLY STRIPPED IN A ROTATING BARREL AND, IN MOST CASES, THE SMUT WILL BE REMOVED BY THE TUMBLING ACTION DURING THE STRIPPING CYCLE. GOOD SUCCESS HAS ALSO BEEN ACHIEVED WITH AN ENCLOSED STRIPPING SYSTEM, PUTTING HOT WATER, B-9 STRIPPER (IN THE CORRECT QUANTITY) AND THE PARTS IN AN ENCLOSED BARREL AND SLOWLY TUMBLING.

POST TREATMENT

THE BLACK SMUT REMAINING ON STRIPPED PARTS IS A COMBINATION OF NICKEL OXIDES AND NICKEL SULFIDES AND CAN BE REMOVED BY ANY ONE OF THE FOLLOWING METHODS:

1. IF HEXAVALENT CHROMIUM (APP. 1 LB/GAL) OR CYANIDE (APP. 4 OX/GAL) IS IN HOUSE, A POST DIP IN EITHER WILL REMOVE THE NICKEL SMUT.
2. TO REMOVE SMUT FROM STEEL PARTS, THE USE OF REVERSE CURRENT AT SIX OR MORE VOLTS WHILE THE PART IS IN THE STRIP TANK IS EFFECTIVE BUT MAY SHORTEN THE BATH'S LIFE.
3. A SEPARATE BATH MADE UP OF 50% SPENT STRIP AND 50% NEW STRIP (MADE UP AT 1 LB/GAL) WITH REVERSE CURRENT AT SIX OR MORE VOLTS IS BEING WIDELY USED.
4. FOR REMOVAL OF SMUT FROM STEEL, COPPER, OR ZINC DIECAST, THE FOLLOWING FORMULATION WILL QUICKLY REMOVE ALL SMUT WITH NO ETCHING OF THE ZINC OR COPPER:

   (A) N.T.A. TRISODIUM SALT: 1/3 - 1/2 LB/GALLON
   (NITRILOTRIACETIC ACID - AVAILABLE FROM W.R.GRACE OR DUPONT)

   (B) 35% HYDROGEN PEROXIDE: 5 - 10% BY VOLUME

   BECAUSE OF THE SHORT LIFE OF HYDROGEN PEROXIDE, THIS DIP MUST BE MADE UP ON A DAILY BASIS AND THE SAME DISPOSAL METHODS USED FOR ANY CHELATED MATERIAL SHOULD BE FOLLOWED.
5. IF STRIPPING A THIN ELECTROLYTIC NICKEL (.2 - .4 MILS) THE SMUT WILL ALSO BE THIN AND CAN USUALLY BE REMOVED DURING YOUR NORMAL CLEANING PROCESS PRIOR TO REPLATING: ELECTROCLEAN, RINSE, AND ACID DIP. IF RESIDUAL SMUT IS DETECTED AFTER ACID, REPEAT PROCESS.

CONT.....

REMOVING ELECTROLESS NICKEL FROM STEEL WITH B-9 NICKEL STRIPPER

B-9 NICKEL STRIPPERS GIVE SUPERIOR RESULTS WHEN USED FOR REMOVAL OF ELECTROLESS NICKEL COATINGS. WHEN STRIPPING ELECTROLESS NICKEL CONTAINING NO MORE THAN 11% PHOSPHORUS, FOLLOW THE SAME PROCEDURES LISTED ON PAGES #2 AND 3.

WHEN STRIPPING BRIGHT ELECTROLESS NICKEL IN A NEW BATH UP TO HALF LIFE, THE SMUT WILL BE DISSOLVED IF THE PARTS ARE ALLOWED TO REMAIN IN THE BATH FOR 1-2 HOURS AFTER THE STRIPPING IS COMPLETED. THE STRIPPER SOLUTION SHOULD NOT AFFECT THE BASE METAL. THIS PROCESS, HOWEVER, IS NOT AS EFFECTIVE AFTER THE BATH PASSES HALF-LIFE.

FAST REMOVAL OF HIGH PHOSPHORUS ELECTROLESS NICKEL COATINGS (11 - 15%) CAN BE ACHIEVED BY APPLYING 3 VOLTS OF REVERSE CURRENT TO THE PARTS DURING THE STRIPPING CYCLE. THIS ELECTROCHEMICALLY ENHANCED STRIPPING PROCESS IS AN IMPORTANT NEW DEVELOPMENT IN SOLUBILIZING HIGH PHOSPHORUS ELECTROLESS NICKEL DEPOSITS.(PATENTED) THE ELECTRICAL CURRENT IS UTILIZED ONLY TO DISSOLVE THE PHOSPHORUS IN THE DEPOSIT, ALLOWING THE B-9 TO THEN STRIP THE NICKEL. TO APPLY THE REVERSE CURRENT, WE RECOMMEND AN ELECTRICAL D.C. POWER UNIT OF SIX OR MORE VOLTS WITH THE CAPACITY TO PROVIDE TWENTY AMPS PER SQUARE FOOT OF SURFACE AREA. CAUTION: THIS PROCEDURE MAY ETCH A COPPER-BASED ALLOY AND SHOULD BE EMPLOYED FOR STEEL SUBSTRATES ONLY.

YOUR ELECTROLESS NICKEL BATH CONTAINS STABILIZERS WHICH PREVENT BATH COLLAPSE AND SPONTANEOUS PLATEOUT. AFTER STRIPPING, THESE STABILIZER ARE CONCENTRATED IN THE SMUT. OCCASIONALLY, A STRIPPED PART THAT LOOKS SMUT-FREE ACTUALLY HAS TRAPPED STABILIZERS WHICH CLING INVISIBLY IN THE CRACKS AND PORES OF THE METAL AND MAY CAUSE PITTING WHEN THE PART IS REPLATED. IF PITTING OCCURS, WE HIGHLY RECOMMEND THE ELECTRICAL SMUT REMOVAL PROCESS DESCRIBED IN THE "POST TREATMENT" SECTIONS (PAGE #3) BE EMPLOYED AFTER STRIPPING.

REMOVING ELECTROLYTIC NICKEL FROM BRASS, COPPER, ZINC DIECAST, SILVER, AND GOLD WITH B-929 NICKEL STRIPPER

THE B-929 NICKEL STRIPPER FORMULATION CONTAINS SULFUR WHICH INHIBITS COPPER CONTAMINATION AND EXTENDS THE LIFE OF YOUR STRIPPING BATH. THE SULFUR CONTENT OF THE BATH SHOULD BE MAINTAINED BY THE PLATER AT A RATE OF ABOUT A 2 OUNCE ADDITION PER SHIFT OF OPERATION OR AS NEEDED BY VISUALLY CHECKING THE BATH. IF SULFUR IS FLOATING ON AND IN THE BATH,

CONT.....

NO ADDITION WILL BE NEEDED. YOU NEED NOT WORRY ABOUT ADDING TOO MUCH SULFUR TO YOUR BATH. IT WILL BE USED AS IT IS NEEDED AND AN OVERADDITION WILL HAVE NO ILL EFFECTS ON THE BATH.

AN ADDITIONAL BENEFIT OF THE B-929 FORMULATION IS THE GREAT REDUCTION, OR POSSIBLY COMPLETE ELIMINATION, OF SMUT BUILD-UP, ESPECIALLY ON THE THINNER NICKEL PLATES. THE HYDROGEN PEROXIDE FORMULATION LISTED IN THE "POST TREATMENT" SECTION OF PAGE #3 WILL EFFICIENTLY REMOVE ANY REMAINING SMUT WITHOUT ATTACK ON YOUR SUBSTRATES.

THE B-929 IS MADE UP AND OPERATED USING EXACTLY THE SAME PROCEDURES AS THE B-9. PLEASE REFER TO PAGES #2 AND #3 FOR COMPLETE INSTRUCTIONS ON MAKE-UP AND OPERATION.

REMOVING NICKEL-IRON PLATE WITH B-9 NICKEL-IRON STRIPPER

THE ONLY VARIATION IN USAGE OF THE B-9 NICKEL-IRON STRIPPER IS IN THE MAKE-UP:

1. FILL THE STRIPPING TANK HALF FULL OF 120^{o}-150^{o}F WATER.
2. ADD THREE POUNDS OF THE B-9 NICKEL-IRON STRIPPER FOR EACH GALLON OF THE TANK'S WORKING CAPACITY.
3. COMPLETE FILLING THE TANK WITH WARM WATER AND STIR WHILE HEATING TO THE OPERATING TEMPERATURE OF 120^{o}-150^{o}F.
4. CHECK pH OF THE BATH. IT SHOULD BE 9.2 - 9.8. IF LOWER, RAISE THE pH BY SLOWLY ADDING SODA ASH WHILE STIRRING.
5. WHEN THE PROPER pH HAS BEEN ATTAINED, THE PROPER TEMPERATURE REACHED, AND THE POWDER DISSOLVED, YOUR B-9 NICKEL-IRON STRIPPER BATH IS READY TO USE. FOLLOW "BATH OPERATION PROCEDURE" AND "POST TREATMENT PROCEDURES" OUTLINED ON PAGE #3.

DISPOSAL

THE FOLLOWING DISPOSAL METHODS ARE CURRENTLY BEING EMPLOYED BY SOME B-9, B-929, AND B-9 NICKEL-IRON USERS:

1. IN CONSULTATION WITH LICENSED WASTE DISPOSAL COMPANIES, WE HAVE BEEN ADVISED THAT, BECAUSE OF THE NON-TOXIC FORMULATION OF THE B-9 PRODUCTS, THE SPENT SOLUTION IS CLASSIFIED AS INDUSTRIAL WASTE RATHER THAN HAZARDOUS WASTE. THE INDUSTRIAL WASTE CLASSIFICATION IS DUE TO THE NICKEL IN THE SOLUTION. THIS CLASSIFICATION RESULTS IN HAUL-OFF CHARGES AS SMALL AS .50/GALLON OR LESS AND IS, IN MANY CASES, MORE ECONOMICAL THAN TREATING WITHIN YOUR FACILITIES. THE OPERATOR SHOULD TAKE CARE THAT HE DOES NOT INTRODUCE CHROMIUM INTO HIS STRIPPING BATH; THEREBY CAUSING THE SOLUTION TO BE CLASSIFIED

CONT......

AS HAZARDOUS WASTE.

2. THE ADDITION OF VINMET 1140 (SODIUMDIMETHYLDITHIOCARBAMATE) RESULTS IN AN IMMEDIATE PRECIPITATION OF THE NICKEL IN YOUR SPENT STRIPPING BATH, CREATING A SLUDGE WHICH CAN THEN BE PROCESSED THROUGH YOUR FILTER PRESS. THE RESIDUAL LIQUID MAY BE TREATED BY BEING SLOWLY FED (AFTER REVIEW BY YOUR WASTE DISPOSAL CONSULTANTS) THROUGH YOUR WASTE TREATMENT SYSTEM. THE ABOUT NAMED CHEMICAL CAN BE OBTAINED FROM: VININGS CHEMICAL COMPANY, 1650 CANTON ROAD, MARIETTA, GA. OR THROUGH YOUR LOCAL B-9 DISTRIBUTOR.
3. PLATING OUT THE NICKEL FROM THE SPENT STRIPPING BATH IS ALSO BEING SUCCESSFULLY EMPLOYED. AGAIN, THE RESIDUAL LIQUID IS SLOWLY FED THROUGH YOUR WASTE TREATMENT SYSTEM. SOME OPERATORS MAY WANT TO EMPLOY THIS PLATE-OUT TREATMENT ALONG WITH A CHEMICAL TREATMENT.
4. VARIOUS OTHER METHODS OF NICKEL REMOVAL INCLUDE CELLULOSE XANTHATE CHEMICAL PRECIPITATION, ION EXCHANGE, AND SULFIDE PRECIPITATION.

TO ANALYZE YOUR STRIPPING BATH FOR NICKEL CONTENT

REAGENTS NEEDED: CONCENTRATED AMMONIUM HYDROXIDE

MUREXIDE MIX (1 GRAM OF MUREXIDE MIXED WITH 100 GRAMS OF CP SODIUM CHLORIDE)

E.D.T.A. (DISODIUM DIHYDRATE SALT) 0.1M, 37.2350 GRAMS PER LITER

PIPETTE A 10 ML SAMPLE INTO A 250 ML ERLENMEYER FLASK. DILUTE TO 100 ML WITH D.I. WATER. ADD 10 ML AMMONIUM HYDROXIDE. ADD MUREXIDE MIX IN A QUANTITY EQUAL IN SIZE TO THE HEAD OF A LARGE KITCHEN MATCH. TITRATE WITH 0.1M E.D.T.A. TO A VIOLET-PURPLE END POINT.

CALCULATION: NUMBER MLS 0.1M E.D.T.A. TITRATED X .078 FACTOR = OZ/GAL NICKEL METAL. ADD .60 LBS NICKEL STRIPPER PER GALLON OF TANK VOLUME PER OUNCE OF NICKEL TO BRING STRIPPING BATH BACK TO ORIGINAL CONDITION.

EXAMPLE: 100 GALLON TANK

ANALYZATION #1: NICKEL ANALYZED AT .50 OUNCES PER GALLON. MULTIPLY .60 X 100 GALLONS X .50 OUNCES NICKEL = 30 LBS REQUIRED ADDITION.

ANALYZATION #2: NICKEL ANALYZED AT TOTAL OF 1.25 OZ/GAL. SUBTRACT THE PREVIOUS ANALYSIS: 1.25 = .50 = .75 OZ/GAL NICKEL ADDED. MULTIPLY .60 X 100 GALLONS X .75 OUNCES NICKEL = 45 LBS REQUIRED ADDITION.

-END-

Material Safety Data Sheet

B-9 NICKEL STRIPPERS

QUICK IDENTIFIER
Common Name: (used on label and list)

May be used to comply with OSHA's Hazard Communication Standard, 29CFR 1910. 1200. Standard must be consulted for specific requirements.

SECTION 1 -

Name: METALX, INC.

Address: ROUTE 10, BOX 683

City, State, and ZIP: LENOIR, N. C. 28645

Signature of Person Responsible for Preparation (Optional)

Emergency Telephone No.: 704-758-4997

Other Information Calls: 704-758-4997

Date Prepared: 6/86

SECTION 2 – HAZARDOUS INGREDIENTS/IDENTITY

Hazardous Component(s) (chemical & common name(s))	OSHA PEL	ACGIH TLV	Other Exposure Limits	* (optional)	CAS NO.

B-9, B-929, B-9 NICKEL/IRON STRIPPERS

B-9, B-929, AND B-9 NICKEL/IRON NICKEL STRIPPERS ARE PROPRIETARILY COMPOUNDED MATERIALS AND ARE DEEMED A TRADE SECRET UNDER 29 CFR AND, ACCORDING TO 16 CFR, ARE NON-TOXIC ORALLY. THESE PRODUCTS MAY CONTAIN SODIUM CARBONATE (SODA ASH - AS IN LAUNDRY DETERGENT) AND MAY CAUSE EYE/SKIN IRRITATION.

SECTION 3 - PHYSICAL & CHEMICAL CHARACTERISTICS

Boiling Point: N/A

Specific Gravity ($H_2O = 1$): 8.3 LB/GAL.

Vapor Pressure (mm Hg): N/A

Vapor Density (Air = 1):

Solubility in Water: COMPLETELY SOLUBLE

Reactivity in Water:

Appearance and Odor: OFF-WHITE TO YELLOW GRANULAR POWDER

Melting Point: N/A

SECTION 4 – FIRE & EXPLOSION DATA

Flash Point: 550°F. C.

Method Used:

Flammable Limits in Air % by Volume: LEL Lower / UEL Upper

Auto-Ignition Temperature: N/A

Extinguisher Media: WATER

Special Fire Fighting Procedures: USE WATER ONLY

Unusual Fire and Explosion Hazards: NONE KNOWN

SECTION 5 – PHYSICAL HAZARDS (REACTIVITY DATA)

Stability Unstable ☐ Stable ☒ Conditions to Avoid: Avoid temperatures over 500°F.

Incompatibility (Materials to Avoid): Oxidizing agents

Hazardous Decomposition Products: Unknown

Hazardous Polymerization: May Occur ☐ Will Not Occur ☒ Conditions to Avoid: Avoid temperatures over 500°F and oxidizing agents

SECTION 6 – HEALTH HAZARDS

1. Acute 2. Chronic
None known 16 CFR part 1500.3 - considered non-toxic orally

Signs and Symptoms of Exposure: This product may contain sodium carbonate (soda ash, as in laundry detergent) and may cuase eye-skin irritation

Medical Conditions Generally Aggravated by Exposure: Persons with severe allergeic reactions should avoid all chemicals. Avoid inhalation of dust.

Chemical Listed as Carcinogen or Potential Carcinogen: None National Toxicology Program Yes ☐ No ☐ I.A.R.C. Monographs Yes ☐ No ☐ OSHA Yes ☐ No ☐

Emergency and First Aid Procedures: For eyes and skin, flush with copious amounts of water. If irritation persists, seek medical attention.

ROUTES OF ENTRY

1. Inhalation: Non-toxic
2. Eyes: Slight Irritant
3. Skin: Slight Irritant
4. Ingestion: Non-toxic

SECTION 7 - SPECIAL PRECAUTIONS AND SPILL/LEAK PROCEDURES

Precautions to be Taken in Handling and Storage: Safe and acceptable warehouse practices. Avoid temperatures over 500°F.

Other Precautions: Biodegradability Information: C.O.D. mgO_2/kg. 331,000 ~~Product~~ is deemed biodegradab
B.O.D.$_5$ mgO_2/kg 231,000

Steps to be Taken in Case Material is Released or Spilled: Sweep up solids - wash residue into sewer with water.

Waste Disposal Methods (Consult federal, state, and local regulations): Into sewer in accordance with local regulations governing disposal of solid, soluble non-hazardous wastes.

SECTION 8 – SPECIAL PROTECTION INFORMATION/CONTROL MEASURES

Respiratory Protection (Specify Type): OSHA approved nuisance dust mask recommended

Ventilation: Local Exhaust suggested Mechanical (General) suggested Special Other

Protective Gloves: recommended Eye Protection: recommended

Other Protective Clothing or Equipment: None specific

Work/Hygienic Practices: Standard safe handling procedures

IMPORTANT
Do not leave any blank spaces. If required information is unavailable, unknown, or does not apply, so indicate.

CU-F1R Printed by Labelmaster, Division of American Labelmark Company, Inc. Chicago, IL 60646-6719 1-800-621-5808 • (321) 478-0900

TECHNIC INC.
CRANSTON, RHODE ISLAND

technical data

CY-LESS ELECTROLYTIC GOLD STRIP

MAKEUP: Ready-to-use.

OPERATING CONDITIONS:

Tanks	-	Plastic, Glass, Stainless Steel
Temperature	-	40-60°C
Agitation	-	Preferable.
Cathodes	-	Stainless steel mesh or panels in polypropylene bags to prevent the loosely deposited gold from becoming suspended in the strip solution.
Filtration	-	If the cathodes are not bagged, use a polypropylene cartridge filter to remove the suspended gold from the strip solution.
Current Density	-	20-80 ASF (Optimum 50 ASF)
Stripping rate	-	20-90 microinches/minute
pH	-	3-5 (preferably 4.5)

NOTE: The stripping rate can be increased by changing the ratio of components and increasing the Current Density.

FB 10/21/85

TECHNIC INC.

POST OFFICE BOX 965, PROVIDENCE, R.I. 02901 (401) 781-6100 ARLINGTON HTS., ILL. (312) 398-1220/ANAHEIM, CAL. (714) 632-0200/SAN JOSE, CAL. (408) 287-3732/IRVING, TEXAS (214) 790-8500/HONG KONG: 011-852-0-253721/KOREA: 784-1201/CANADA: BRUDAC Canada, Inc. - Leach & Garner, Canada, Ltd./EUROPE: Schering AG 011-49-30-468-2688

MATERIAL SAFETY DATA SHEET

I. PRODUCT IDENTIFICATION

Trade name (as labeled) ELECTROLYTIC CY-LESS GOLD STRIP

Chemical names, common names: Thiourea

Manufacturer's name Technic, Inc.

Address 1 Spectacle Street
Cranston, RI 02910

Emergency phone 401/781-6100

Name of Preparer: William A. Wilson

Date prepared: June 21, 1988

II. HAZARDOUS INGREDIENTS

Chemical Names	CAS Numbers	Percent	Exposure Limits
Thiourea $H_2N-\underset{\underset{S}{\parallel}}{C}-NH_2$	62-56-6	2.80	PEL = not determined TLV = not determined

The remainder of the product consists of inorganic salts and salt of benzoic acid that are non-toxic.

III. PHYSICAL PROPERTIES

Vapor density (air=1) N.A.

Melting point or range, F N.A.

Specific gravity = 1.08

Boiling point or range, F not determined

Solubility in water Soluble

Vapor pressure, mmHg at 20 C N.A.

Evaporation rate (butyl acetate = 1) N.A.

Appearance and odor Slightly yellow solution; no odor

IV. FIRE AND EXPLOSION

Flash Point, F (give method) N.A. (does not burn)

Autoignition temperature, F N.A.

Flammable limits in air, volume %: lower N.A. upper N.A.

Fire extinguishing materials:

N.A. water spray N.A. carbon dioxide N.A. other:

N.A. foam N.A. dry chemical

Special firefighting procedures:

none

Unusual fire and explosion hazards:

none

PRECIOUS METAL PLATING SOLUTIONS AND EQUIPMENT

------------------ V. HEALTH HAZARD INFORMATION --------------------

SYMPTOMS OF OVEREXPOSURE for each potential route of exposure.

Inhaled: Irritation of the respiratory tract, nausea.

Contact with skin or eyes: Irritation, allergic skin eruptions.

Absorbed through skin: No

Swallowed: Nausea, vomiting, cramps.

HEALTH EFFECTS OR RISKS FROM EXPOSURE. Explain in lay terms. Attach extra page if more space is needed.

~~Acute~~: Said to cause depression of bone marrow with anemia, leukopenia, thrombocytopenia and agrenolocytocis. May cause allergic skin eruptions. Rapidly execreted unchanged in urine.

~~Chronic~~: Thiourea is listed in the chemical literature as having carcinogenic risk. As with all chemicals, this product should be handled only by trained personnel, cognizant of the potential hazards and using appropriate protective measures.

FIRST AID: EMERGENCY PROCEDURES

Eye contact: Flush with large amounts of water (under lids) for 15 minutes or longer. Consult physician.

Skin contact: Wash thoroughly with soap and water. Consult physician.

Inhaled: Remove to fresh air. If breathing difficulties persist, consult physician.

Swallowed: Consult physician immediately. Induce vomiting by sticking finger down throat. Keep patient warm.

SUSPECTED CANCER AGENT?

___ NO.

X YES: IARC (animal positive)

------------------------ VI. REACTIVITY DATA ------------------------

Stability: X Stable ___ Unstable

Conditions to avoid: None

Incompatibility (materials to avoid): None

Hazardous decomposition products (including combustion products): Nitrogen and sulfur oxides

Hazardous polymerization: ___ May occur X Will not occur

Conditions to avoid: None

------------ VII. SPILL, LEAK AND DISPOSAL PROCEDURES ------------

Spill response procedures (include employee protection measures):

Contain spill and absorb with absorbant. Sweep into covered plastic containers and send to Technic for refining (contains gold if used). See note below.

NOTE: Dispose of all wastes in accordance with Federal, State and Local regulations.

--------------- VIII. SPECIAL HANDLING INFORMATION ---------------

Ventilation and engineering controls: Local exhaust

Respiratory protection: Not required

Eye protection (type): Yes - safety glasses with side shields or chemical goggles

Gloves (specify material): Rubber gloves

Other clothing and equipment: Not required

Work practices, hygienic practices: Wash thoroughly after handling and before eating or smoking. Avoid skin contact.

Other handling and storage requirements: Store in a cool dry place away from food and feed products.
Keep container closed.

WW 5/86

#1

TECHNIC INC.
CRANSTON, RHODE ISLAND

technical data

NON-CYANIDE SILVER STRIPPER
(Electrolytic)

Techni Strip NC Ag is a non-cyanide stripper for silver from various base metals used with reverse current.

FORMULATION:

Techni Strip NC Ag	6 ozs./gallon
Potassium Hydroxide	1.5 ozs./gallon

PREPARATION:

1) Fill tank to two-thirds full with clean tap water.
2) Heat to 100^{O}F.
3) Add 1.5 ozs./gallon potassium hydroxide.
4) Add 6 ozs./gallon Techni Strip NC Ag.
5) Bring to volume - stir well.

OPERATING CONDITIONS:

Tanks	-	Stainless, enamel, glass, or polypro.
Temperature	-	100 - 140^{O}F
Time	-	Removes 100 millionths in two minutes
Voltage	-	3 to 6 volts - make work anodic
Agitation	-	Moderate
*Cathodes	-	S/S
Replenishment	-	Replenish until Techni Strip NC Ag totals 12 ozs./gallon.

*Silver can be stripped from cathodes with 50% nitric acid.

EGB 11/81

TECHNIC, INC.
MATERIAL SAFETY DATA SHEET

SECTION I — PRODUCT IDENTIFICATION

TRADE NAME (as labeled): NON-CYANIDE SILVER STRIPPER (Electrolytic)

CHEMICAL NAMES, COMMON NAMES: Succinimide, Butanimide, 2,5-pyrrolidinedione

MANUFACTURER'S NAME & ADDRESS:
TECHNIC, INC.
1 SPECTACLE STREET
CRANSTON, RI 02910
EMERGENCY PHONE: (401)781-6100

NAME OF PREPARER: WILLIAM A. WILSON

DATE PREPARED: September 17, 1991

24 hour Emergency: Chem Trec 1-800-424-9300

SECTION II — HAZARDOUS INGREDIENTS

CHEMICAL NAMES	CAS NUMBER	P. RCENT	EXPOSURE LIMITS
Succinimide $C_4H_5O_2N$	123-56-8	> 95%	TLV = Not established.

This product is not regulated as a toxic chemical under Section 313 of Title III/SARA, and 40 CFR, Part 372.
This product is not regulated by the California Proposition 65 list.
All ingredients are listed in the TSCA inventory.

SECTION III — PHYSICAL PROPERTIES

VAPOR DENSITY (AIR=1)	N.A.	SPECIFIC GRAVITY:	1.418
VAPOR PRESSURE (mm Hg)	N.A.	MELTING POINT (degrees F)	255 ° F
EVAPORATION RATE (BUTYL ACETATE=1)	N.A.	BOILING POINT (degrees F)	N.A.
SOLUBILITY IN WATER:	Soluble.		

APPEARANCE AND ODOR: Cream colored to colorless flakes; odorless.

SECTION IV. — FIRE AND EXPLOSION

FLASH POINT (°F) (METHOD USED): N.A.

AUTOIGNITION TEMPERATURE, F. N.A.

FLAMMABLE LIMITS IN AIR, VOLUME %: LOWER LIMIT N.A. UPPER LIMIT N.A.

FIRE EXTINGUISHING MATERIALS:

X WATER SPRAY X CARBON DIOXIDE ____ OTHER:
X FOAM X DRY CHEMICAL

SPECIAL FIREFIGHTING PROCEDURES: Use self-contained breathing apparatus.

UNUSUAL FIRE AND EXPLOSION HAZARDS: None.

SECTION V — HEALTH HAZARD INFORMATION

SYMPTOMS OF OVER-EXPOSURE FOR EACH POTENTIAL ROUTE OF EXPOSURE.

INHALATION: Dust irritant.

CONTACT WITH SKIN OR EYES: Not known.

ABSORBED THROUGH SKIN: Not known.

SWALLOWED: Not known.

HEALTH EFFECTS OR RISKS FROM EXPOSURE. EXPLAIN IN LAY TERMS. ATTACH EXTRA PAGE IF MORE SPACE IS NEEDED.

ACUTE: Local: Not known.

Systemic: Not known.

CHRONIC: Local: Not known.

Systemic: Not known.

FIRST AID: EMERGENCY PROCEDURES

EYE CONTACT: Flush with water (15 minutes or more). Call physician.

SKIN CONTACT: Wash thoroughly with soap and water. Call physician.

INHALED: Remove to fresh air. If breathing difficulties develop or persist, maintain respiration and call physician.

SWALLOWED: Induce vomiting and seek medical assistance immediately.

SUSPECTED CANCER AGENT? X NO ____ YES

SECTION VI — REACTIVITY DATA

STABILITY: X STABLE ____ UNSTABLE

CONDITIONS TO AVOID: Avoid heat and open flames.

INCOMPATIBILITY (MATERIALS TO AVOID): Water and base materials.

HAZARDOUS DECOMPOSITION PRODUCTS (INCLUDING COMBUSTION PRODUCTS): Carbon oxides and nitrogen oxide may be emitted on combustion.

HAZARDOUS POLYMERIZATION: ____ MAY OCCUR X WILL NOT OCCUR

CONDITIONS TO AVOID: None.

SECTION VII — SPILL, LEAK AND DISPOSAL PROCEDURES

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED:

Sweep up into a steel drum. Incinerate in a waste solvent solution in a furnace fitted with an after-burner and alkali scrubber.

See Section VIII for employee protection.

WASTE DISPOSAL: SHOULD BE IN ACCORDANCE WITH FEDERAL, STATE, AND LOCAL ENVIRONMENTAL CONTROL REGULATIONS.

SECTION VIII — SPECIAL HANDLING INFORMATION

VENTILATION:	Local exhaust.
RESPIRATORY PROTECTION:	Use NIOSH approved air purifying respirator with appropriate cartridge in a major spill.
EYE PROTECTION:	Safety glasses with side shields or face shield.
GLOVES:	Rubber gloves.
OTHER CLOTHING AND EQUIPMENT:	Rubber apron is optional. Long-sleeved shirts.
WORK PRACTICES, HYGIENIC PRACTICES:	Wash thoroughly after handling. Do not eat, drink, or smoke in the work area.
OTHER HANDLING AND STORAGE REQUIREMENTS:	Store in a cool, dry place. (55-85 °F) Keep container closed. Avoid breathing dust, or prolonged contact.

HMIS®

H HEALTH	1
F FLAMMABILITY	0
R REACTIVITY	1
PERSONAL PROTECTION	B

APPENDIX C

STRIPPING RATE DATA FOR THE FIELD TESTING AND IMPLEMENTATION OF FREDERICK GUMM'S CLEPO 204

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Stripper	Test Date	Coupon Material	Coupon #	Density (g/cm3)	Unmasked Dimensions in inches length	width	thick	Surface Area (cm2)	Initial Mass (grams)	Final Mass (grams)	Change Mass (grams)	Total Time (hours)	Stripping Rate (mil/hour)	Average S.R. (mil/hour)
120 deg. F														
Clepo 204	6-12-89	410	122	7.70	1.469	1.000	0.063	20.54	17.8398	17.8400	-0.0002	8.00	-6.22E-05	-1.07E-04
Clepo 204	6-12-89	410	126	7.70	1.500	1.000	0.063	20.97	17.9592	17.9597	-0.0005	8.00	-1.52E-04	
Clepo 204	6-12-89	C4340	33	7.84	1.438	1.000	0.063	20.11	14.3959	14.3969	-0.0010	8.00	-3.12E-04	-1.56E-04
Clepo 204	6-12-89	C4340	38	7.84	1.500	1.000	0.063	20.97	14.0943	14.0943	0.0000	8.00	0.00E+00	
Clepo 204	6-12-89	D6AC	73	8.20	1.469	1.000	0.125	22.13	30.6324	30.6324	0.0000	8.00	0.00E+00	-1.38E-04
Clepo 204	6-12-89	D6AC	72	8.20	1.438	1.000	0.125	21.67	30.7118	30.7128	-0.0010	8.00	-2.77E-04	
Clepo 204	6-12-89	321	63	7.92	1.500	1.000	0.063	20.97	18.6013	18.6022	-0.0009	8.00	-2.67E-04	-3.15E-04
Clepo 204	6-12-89	321	62	7.92	1.469	1.000	0.063	20.54	18.5604	18.5616	-0.0012	8.00	-3.63E-04	
Clepo 204	6-12-89	I-718	51	8.60	1.438	1.000	0.063	20.11	15.2737	15.2744	-0.0007	8.00	-1.99E-04	-2.85E-04
Clepo 204	6-12-89	I-718	59	8.60	1.438	1.000	0.063	20.11	15.0732	15.0745	-0.0013	8.00	-3.70E-04	
Clepo 204	6-12-89	HA 188	83	9.70	1.438	1.000	0.125	21.67	35.5892	35.5904	0.0012	8.00	2.81E-04	6.02E-05
Clepo 204	6-12-89	HA 188	84	9.70	1.469	1.000	0.125	22.13	36.1068	36.1075	-0.0007	8.00	-1.61E-04	
Clepo 204	6-12-89	Cu	139	8.92	1.469	1.000	0.125	22.13	28.4421	28.1556	0.2865	8.00	7.14E-02	7.64E-02
Clepo 204	6-12-89	Cu	161	8.92	1.500	1.000	0.125	22.58	27.9632	27.6303	0.3329	8.00	8.13E-02	
Clepo 204	6-12-89	410	121	7.70	1.500	1.000	0.063	20.97	15.2349	15.2351	-0.0001	24.00	-1.02E-05	-1.02E-05
Clepo 204	6-12-89	410	123	7.70	1.500	1.000	0.063	20.97	18.0218	18.0216	-0.0001	24.00	-1.02E-05	
Clepo 204	6-12-89	C4340	37	7.84	1.469	1.000	0.063	20.54	13.9071	13.9073	-0.0001	24.00	-1.02E-05	-3.06E-05
Clepo 204	6-12-89	C4340	34	7.84	1.469	1.000	0.063	20.54	14.3443	14.3438	-0.0005	24.00	-5.09E-05	
Clepo 204	6-12-89	D6AC	100	8.20	1.500	1.000	0.125	22.58	30.6604	30.6601	0.0002	24.00	1.77E-05	-4.70E-06
Clepo 204	6-12-89	D6AC	99	8.20	1.469	1.000	0.125	22.13	30.7428	30.7440	-0.0003	24.00	-2.71E-05	
Clepo 204	6-12-89	321	65	7.92	1.469	1.000	0.063	20.54	18.7037	18.7044	0.0000	24.00	0.00E+00	9.88E-06
Clepo 204	6-12-89	321	66	7.92	1.500	1.000	0.063	20.97	18.4906	18.4910	0.0002	24.00	1.98E-05	
Clepo 204	6-12-89	I-718	49	8.60	1.469	1.000	0.063	20.54	15.1058	15.1053	-0.0005	24.00	-4.64E-05	-3.23E-05
Clepo 204	6-12-89	I-718	50	8.60	1.500	1.000	0.063	20.97	15.2913	15.2913	-0.0002	24.00	-1.82E-05	
Clepo 204	6-12-89	HA 188	75	9.70	1.531	1.000	0.125	23.03	35.8509	35.8514	0.0003	24.00	2.20E-05	-1.10E-05
Clepo 204	6-12-89	HA 188	76	9.70	1.531	1.000	0.125	23.03	35.9118	35.9127	-0.0006	24.00	-4.41E-05	
Clepo 204	6-12-89	Cu	182	8.92	1.500	1.000	0.125	22.58	28.0624	27.2421	2.2273	24.00	1.81E-01	1.95E-01
Clepo 204	6-12-89	Cu	190	8.92	1.500	1.000	0.125	22.58	28.8398	28.0525	2.5628	24.00	2.09E-01	
Clepo 204	6-12-89	Ni-S	341	8.90	1.531	1.000	0.063	21.40	24.6233	24.5392	0.0841	1.00	1.74E-01	2.29E-01
Clepo 204	6-12-89	Ni-S	342	8.90	1.500	1.000	0.063	20.97	25.6221	25.5276	0.1345	1.00	2.84E-01	
Clepo 204	6-12-89	Ni-P	7	8.90	1.469	1.000	0.063	20.54	18.8325	18.8165	0.0160	1.00	3.45E-02	2.30E-02
Clepo 204	6-12-89	Ni-P	80	8.90	1.469	1.000	0.063	20.54	18.9639	18.9585	0.0054	1.00	1.16E-02	
Clepo 204	6-12-89	Ni-S	383	8.90	1.500	1.000	0.063	20.97	22.5559	22.4019	0.1540	2.00	1.62E-01	2.76E-01
Clepo 204	6-12-89	Ni-S	412	8.90	1.500	1.000	0.063	20.97	24.1623	23.7925	0.3698	2.00	3.90E-01	
Clepo 204	6-12-89	Ni-P	99	8.90	1.500	1.000	0.063	20.97	18.8348	18.7465	0.0883	2.00	9.31E-02	7.71E-02
Clepo 204	6-12-89	Ni-P	199	8.90	1.500	1.000	0.063	20.97	18.4498	18.3920	0.0578	2.00	6.10E-02	
140 deg. F														
Clepo 204	6-9-89	410	3	7.70	1.531	1.000	0.063	21.40	18.1429	18.1429	0.0000	8.00	0.00E+00	0.00E+00
Clepo 204	6-9-89	410	7	7.70	1.531	1.000	0.063	21.40	17.7625	17.7625	0.0000	8.00	0.00E+00	
Clepo 204	6-9-89	C4340	63	7.84	1.500	1.000	0.063	20.97	14.2511	14.2510	0.0001	8.00	2.99E-05	-4.49E-05
Clepo 204	6-9-89	C4340	64	7.84	1.500	1.000	0.063	20.97	14.1795	14.1799	-0.0004	8.00	-1.20E-04	
Clepo 204	6-9-89	D6AC	95	8.20	1.500	1.000	0.125	22.58	30.6563	30.6557	0.0006	8.00	1.59E-04	1.73E-04
Clepo 204	6-9-89	D6AC	96	8.20	1.500	1.000	0.125	22.58	30.5776	30.5769	0.0007	8.00	1.86E-04	
Clepo 204	6-9-89	321	21	7.92	1.500	1.000	0.063	20.97	18.1998	18.1995	0.0003	8.00	8.89E-05	4.45E-05
Clepo 204	6-9-89	321	23	7.92	1.500	1.000	0.063	20.97	18.3722	18.3722	0.0000	8.00	0.00E+00	

Stripper	Test Date	Coupon Material	Coupon #	Density (g/cm3)	Unmasked Dimensions in inches length	width	thick	Surface Area (cm2)	Initial Mass (grams)	Final Mass (grams)	Change Mass (grams)	Total Time (hours)	Stripping Rate (mil/hour)	Average S.R. (mil/hour)
Clepo 204	6-9-89	I-718	44	8.60	1.531	1.000	0.063	21.40	15.0083	15.0080	0.0003	8.00	8.02E-05	8.11E-05
Clepo 204	6-9-89	I-718	47	8.60	1.500	1.000	0.063	20.97	14.8145	14.8142	0.0003	8.00	8.19E-05	
Clepo 204	6-9-89	HA 188	79	9.70	1.438	1.000	0.125	21.67	35.6380	35.6382	-0.0002	8.00	-4.68E-05	-2.34E-05
Clepo 204	6-9-89	HA 188	80	9.70	1.469	1.000	0.125	22.13	35.6735	35.6735	0.0000	8.00	0.00E+00	
Clepo 204	6-9-89	Cu	137	8.92	1.469	1.000	0.125	22.13	27.8537	26.9965	0.8572	8.00	2.14E-01	2.08E-01
Clepo 204	6-9-89	Cu	149	8.92	1.500	1.000	0.125	22.58	28.4800	27.6525	0.8275	8.00	2.02E-01	
Clepo 204	6-9-89	410	5	7.70	1.500	1.000	0.063	20.97	17.5476	17.5477	-0.0002	24.00	-2.03E-05	2.12E-07
Clepo 204	6-9-89	410	2	7.70	1.469	1.000	0.063	20.54	17.6756	17.6755	0.0002	24.00	2.07E-05	
Clepo 204	6-9-89	C4340	65	7.84	1.531	1.000	0.063	21.40	14.0314	14.0315	-0.0002	24.00	-1.96E-05	1.47E-05
Clepo 204	6-9-89	C4340	66	7.84	1.531	1.000	0.063	21.40	14.0979	14.0984	0.0005	24.00	4.89E-05	
Clepo 204	6-9-89	D6AC	97	8.20	1.500	1.000	0.125	22.58	30.6545	30.6543	0.0003	24.00	2.66E-05	-3.78E-05
Clepo 204	6-9-89	D6AC	94	8.20	1.563	1.000	0.125	23.49	30.5565	30.5568	-0.0012	24.00	-1.02E-04	
Clepo 204	6-9-89	321	25	7.92	1.500	1.000	0.063	20.97	18.4326	18.4326	-0.0007	24.00	-6.91E-05	-5.43E-05
Clepo 204	6-9-89	321	22	7.92	1.500	1.000	0.063	20.97	18.2867	18.2865	-0.0004	24.00	-3.95E-05	
Clepo 204	6-9-89	I-718	43	8.60	1.500	1.000	0.063	20.97	15.1075	15.1080	0.0005	24.00	4.55E-05	2.27E-05
Clepo 204	6-9-89	I-718	45	8.60	1.500	1.000	0.063	20.97	15.1857	15.1859	0.0000	24.00	0.00E+00	
Clepo 204	6-9-89	HA 188	77	9.70	1.469	1.000	0.125	22.13	35.6185	35.6182	-0.0005	24.00	-3.82E-05	-5.21E-05
Clepo 204	6-9-89	HA 188	78	9.70	1.531	1.000	0.125	23.03	36.0810	36.0816	-0.0009	24.00	-6.61E-05	
Clepo 204	6-9-89	Cu	151	8.92	1.531	1.000	0.125	23.03	28.0138	25.7865	0.8203	24.00	6.55E-02	6.48E-02
Clepo 204	6-9-89	Cu	164	8.92	1.500	1.000	0.125	22.58	27.6583	28.0955	0.7873	24.00	6.41E-02	
Clepo 204	6-9-89	Ni-S	321	8.90	1.500	1.000	0.063	20.97	23.1569	21.3167	1.8402	1.00	3.88E+00	3.84E+00
Clepo 204	6-9-89	Ni-S	455	8.90	1.438	1.000	0.063	20.11	24.2266	22.4960	1.7306	1.00	3.81E+00	
Clepo 204	6-9-89	Ni-P	203	8.90	1.469	1.000	0.063	20.54	18.8220	18.7456	0.0764	1.00	1.65E-01	1.46E-01
Clepo 204	6-9-89	Ni-P	228	8.90	1.469	1.000	0.063	20.54	18.9554	18.8958	0.0596	1.00	1.28E-01	
Clepo 204	6-9-89	Ni-S	530	8.90	1.469	1.000	0.063	20.54	22.4287	20.5641	1.8646	2.00	2.01E+00	2.15E+00
Clepo 204	6-9-89	Ni-S	540	8.90	1.438	1.000	0.063	20.11	21.5794	19.4904	2.0890	2.00	2.30E+00	
Clepo 204	6-9-89	Ni-P	244	8.90	1.500	1.000	0.063	20.97	18.8754	18.7807	0.0947	2.00	9.99E-02	8.26E-02
Clepo 204	6-9-89	Ni-P	297	8.90	1.438	1.000	0.063	20.11	18.6619	18.0625	0.0594	2.00	6.53E-02	

140 deg. F Small Tank Fresh Solution pH 10.35 (only 5lbs Clepo 204-T)

Stripper	Test Date	Coupon Material	Coupon #	Density (g/cm3)	length	width	thick	Surface Area (cm2)	Initial Mass (grams)	Final Mass (grams)	Change Mass (grams)	Total Time (hours)	Stripping Rate (mil/hour)	Average S.R. (mil/hour)
Clepo 204	6-22-89	410	10	7.70	1.438	1.000	0.063	20.11	17.6711	17.6702	0.0009	24.00	9.53E-05	6.32E-05
Clepo 204	6-22-89	410	76	7.70	1.469	1.000	0.063	20.54	17.4064	17.4061	0.0003	24.00	3.11E-05	
Clepo 204	6-22-89	C4340	54	7.84	1.438	1.000	0.063	20.11	14.8230	14.8232	-0.0002	24.00	-2.08E-05	3.12E-05
Clepo 204	6-22-89	C4340	57	7.84	1.438	1.000	0.063	20.11	14.8671	14.8663	0.0008	24.00	8.32E-05	
Clepo 204	6-22-89	D6AC	11	8.20	1.438	1.000	0.125	21.67	29.7627	29.7618	0.0009	24.00	8.31E-05	4.15E-05
Clepo 204	6-22-89	D6AC	12	8.20	1.500	1.000	0.125	22.58	29.4713	29.4713	0.0000	24.00	0.00E+00	
Clepo 204	6-22-89	321	87	7.92	1.500	1.000	0.063	20.97	19.0770	19.0768	0.0002	24.00	1.98E-05	3.56E-05
Clepo 204	6-22-89	321	88	7.92	1.438	1.000	0.063	20.11	19.1790	19.1785	0.0005	24.00	5.15E-05	
Clepo 204	6-22-89	I-718	64	8.60	1.438	1.000	0.063	20.11	15.1588	15.1586	0.0002	24.00	1.90E-05	2.85E-05
Clepo 204	6-22-89	I-718	66	8.60	1.438	1.000	0.063	20.11	14.7568	14.7564	0.0004	24.00	3.79E-05	
Clepo 204	6-22-89	HA 188	17	9.70	1.469	1.000	0.125	22.13	36.3038	36.3037	0.0001	24.00	7.64E-06	2.25E-05
Clepo 204	6-22-89	HA 188	18	9.70	1.500	1.000	0.125	22.58	35.8458	35.8453	0.0005	24.00	3.74E-05	
Clepo 204	6-22-89	Cu	116	8.92	1.469	1.000	0.125	22.13	28.2674	25.3086	2.9588	24.00	2.46E-01	2.51E-01
Clepo 204	6-22-89	Cu	199	8.92	1.500	1.000	0.125	22.58	28.4991	25.3555	3.1436	24.00	2.56E-01	
Clepo 204	6-22-89	Ni-S	394	8.90	1.469	1.000	0.063	20.54	21.6578	20.4297	1.2281	1.00	2.64E+00	2.72E+00
Clepo 204	6-22-89	Ni-S	523	8.90	1.500	1.000	0.063	20.97	24.7529	23.4272	1.3257	1.00	2.80E+00	
Clepo 204	6-22-89	Ni-P	22	8.90	1.500	1.000	0.063	20.97	18.9925	18.8725	0.1200	1.00	2.53E-01	2.15E-01
Clepo 204	6-22-89	Ni-P	239	8.90	1.375	1.000	0.063	19.25	18.4637	18.3864	0.0773	1.00	1.78E-01	

Stripper	Test Date	Coupon Material	Coupon #	Density (g/cm3)	Unmasked Dimensions in inches length	width	thick	Surface Area (cm2)	Initial Mass (grams)	Final Mass (grams)	Change Mass (grams)	Total Time (hours)	Stripping Rate (mil/hour)	Average S.R. (mil/hour)
140 deg. F	Small Tank	Fresh Solution	pH 11.03	(only 5 lbs Clepo 204-T)										
Clepo 204	6-26-89	410	72	7.70	1.438	1.000	0.063	20.11	17.5967	17.5967	0.0000	24.00	0.00E+00	5.08E-06
Clepo 204	6-26-89	410	75	7.70	1.500	1.000	0.063	20.97	17.3148	17.3147	0.0001	24.00	1.02E-05	
Clepo 204	6-26-89	C4340	58	7.84	1.500	1.000	0.063	20.97	14.8809	14.8808	0.0001	24.00	9.98E-06	1.54E-05
Clepo 204	6-26-89	C4340	59	7.84	1.438	1.000	0.063	20.11	14.8454	14.8452	0.0002	24.00	2.08E-05	
Clepo 204	6-26-89	D6AC	17	8.20	1.469	1.000	0.125	22.13	29.9511	29.9508	0.0003	24.00	2.71E-05	3.66E-05
Clepo 204	6-26-89	D6AC	18	8.20	1.438	1.000	0.125	21.67	30.1037	30.1032	0.0005	24.00	4.62E-05	
Clepo 204	6-26-89	321	84	7.92	1.438	1.000	0.063	20.11	18.7281	18.7279	0.0002	24.00	2.06E-05	1.03E-05
Clepo 204	6-26-89	321	83	7.92	1.469	1.000	0.063	20.54	19.0474	19.0474	0.0000	24.00	0.00E+00	
Clepo 204	6-26-89	I-718	63	8.60	1.500	1.000	0.063	20.97	15.6376	15.6379	-0.0003	24.00	-2.73E-05	-3.64E-05
Clepo 204	6-26-89	I-718	69	8.60	1.500	1.000	0.063	20.97	14.3978	14.3983	-0.0005	24.00	-4.55E-05	
Clepo 204	6-26-89	HA 188	14	9.70	1.500	1.000	0.125	22.58	35.4598	35.4591	0.0007	24.00	5.24E-05	2.80E-06
Clepo 204	6-26-89	HA 188	16	9.70	1.438	1.000	0.125	21.67	35.7631	35.7637	-0.0006	24.00	-4.68E-05	
Clepo 204	6-26-89	Cu	153	8.92	1.500	1.000	0.125	22.58	27.6114	26.2902	1.3212	24.00	1.08E-01	1.30E-01
Clepo 204	6-26-89	Cu	118	8.92	1.500	1.000	0.125	22.58	28.5350	26.6641	1.8709	24.00	1.52E-01	
Clepo 204	6-26-89	Ni-S	547	8.90	1.500	1.000	0.063	20.97	21.8266	21.5704	0.2562	1.00	5.41E-01	5.27E-01
Clepo 204	6-26-89	Ni-S	531	8.90	1.500	1.000	0.063	20.97	23.0483	22.8048	0.2435	1.00	5.14E-01	
Clepo 204	6-26-89	Ni-P	174	8.90	1.438	1.000	0.063	20.11	18.7739	18.7521	0.0218	1.00	4.80E-02	5.41E-02
Clepo 204	6-26-89	Ni-P	97	8.90	1.500	1.000	0.063	20.97	19.2280	19.1994	0.0286	1.00	6.03E-02	
140 deg. F	Small Tank	Fresh Solution	pH 11.5	(only 5lbs Clepo 204-T)										
Clepo 204	6-27-89	410	19	7.70	1.375	1.000	0.063	19.25	17.8178	17.8169	0.0009	24.00	9.96E-05	1.26E-04
Clepo 204	6-27-89	410	20	7.70	1.406	1.000	0.063	19.68	17.6840	17.6826	0.0014	24.00	1.52E-04	
Clepo 204	6-27-89	C4340	141	7.84	1.438	1.000	0.063	20.11	14.8303	14.8302	0.0001	24.00	1.04E-05	4.43E-05
Clepo 204	6-27-89	C4340	138	7.84	1.531	1.000	0.063	21.40	14.8227	14.8219	0.0008	24.00	7.82E-05	
Clepo 204	6-27-89	D6AC	9	8.20	1.469	1.000	0.125	22.13	19.4025	19.4014	0.0011	24.00	9.95E-05	6.74E-05
Clepo 204	6-27-89	D6AC	7	8.20	1.500	1.000	0.125	22.58	21.2258	21.2254	0.0004	24.00	3.54E-05	
Clepo 204	6-27-89	321	16	7.92	1.469	1.000	0.063	20.54	14.1711	14.1711	0.0000	24.00	0.00E+00	2.02E-05
Clepo 204	6-27-89	321	2	7.92	1.469	1.000	0.063	20.54	15.0837	15.0833	0.0004	24.00	4.03E-05	
Clepo 204	6-27-89	I-718	91	8.60	1.469	1.000	0.063	20.54	16.0698	16.0702	-0.0004	24.00	-3.71E-05	-4.64E-06
Clepo 204	6-27-89	I-718	96	8.60	1.469	1.000	0.063	20.54	16.0796	16.0793	0.0003	24.00	2.79E-05	
Clepo 204	6-27-89	HA 188	59	9.70	1.375	1.000	0.125	20.77	17.0849	17.0856	-0.0007	24.00	-5.70E-05	-4.44E-05
Clepo 204	6-27-89	HA 188	57	9.70	1.406	1.000	0.125	21.22	17.1510	17.1514	-0.0004	24.00	-3.19E-05	
Clepo 204	6-27-89	Cu	120	8.92	1.438	1.000	0.125	21.67	28.1646	26.9224	1.2422	24.00	1.05E-01	1.07E-01
Clepo 204	6-27-89	Cu	106	8.92	1.406	1.000	0.125	21.22	27.7060	26.4453	1.2607	24.00	1.09E-01	
Clepo 204	6-27-89	Ni-S	404	8.90	1.500	1.000	0.063	20.97	25.0933	25.0121	0.0812	1.00	1.71E-01	1.83E-01
Clepo 204	6-27-89	Ni-S	389	8.90	1.500	1.000	0.063	20.97	28.5449	28.4522	0.0927	1.00	1.96E-01	
Clepo 204	6-27-89	Ni-P	65	8.90	1.500	1.000	0.063	20.97	19.1730	19.1572	0.0158	1.00	3.33E-02	3.38E-02
Clepo 204	6-27-89	Ni-P	52	8.90	1.500	1.000	0.063	20.97	18.6556	18.6394	0.0162	1.00	3.42E-02	
140 deg. F	Fresh Solution	Small Tank	pH 12.07	(only 5 lbs Clepo 204-T)										
Clepo 204	6-28-89	410	197	7.70	1.500	1.000	0.063	20.97	18.4087	18.4083	0.0004	24.00	4.06E-05	3.09E-05
Clepo 204	6-28-89	410	195	7.70	1.438	1.000	0.063	20.11	17.9592	17.9590	0.0002	24.00	2.12E-05	
Clepo 204	6-28-89	C4340	128	7.84	1.500	1.000	0.063	20.97	14.9247	14.9246	-0.0001	24.00	-9.98E-06	-4.14E-05
Clepo 204	6-28-89	C4340	139	7.84	1.438	1.000	0.063	20.11	15.3035	15.3042	-0.0007	24.00	-7.28E-05	
Clepo 204	6-28-89	D6AC	47	8.20	1.500	1.000	0.094	21.77	20.3916	20.3912	0.0004	24.00	3.68E-05	4.65E-05

Stripper	Test Date	Coupon Material	Coupon #	Density (g/cm3)	Unmasked Dimensions in inches length	width	thick	Surface Area (cm2)	Initial Mass (grams)	Final Mass (grams)	Change Mass (grams)	Total Time (hours)	Stripping Rate (mil/hour)	Average S.R. (mil/hour)
Clepo 204	6-28-89	D6AC	46	8.20	1.469	1.000	0.094	21.33	18.7670	18.7664	0.0006	24.00	5.63E-05	
Clepo 204	6-28-89	321	14	7.92	1.469	1.000	0.063	20.54	14.9164	14.9169	-0.0005	24.00	-5.04E-05	-4.07E-05
Clepo 204	6-28-89	321	11	7.92	1.438	1.000	0.063	20.11	14.9330	14.9336	-0.0003	24.00	-3.09E-05	
Clepo 204	6-28-89	I-718	137	8.60	1.469	1.000	0.063	20.54	16.1510	16.1508	0.0002	24.00	1.86E-05	1.39E-05
Clepo 204	6-28-89	I-718	138	8.60	1.469	1.000	0.063	20.54	16.2239	16.2239	0.0001	24.00	9.29E-06	
Clepo 204	6-28-89	HA 188	64	9.70	1.375	1.000	0.063	19.25	17.0093	17.0095	-0.0002	24.00	-1.76E-05	-4.32E-05
Clepo 204	6-28-89	HA 188	65	9.70	1.406	1.000	0.063	19.68	16.8956	16.8964	-0.0008	24.00	-6.87E-05	
Clepo 204	6-28-89	Cu	110	8.92	1.406	1.000	0.125	21.22	27.9774	27.2601	0.7173	24.00	6.22E-02	7.21E-02
Clepo 204	6-28-89	Cu	145	8.92	1.469	1.000	0.125	22.13	28.3370	27.3492	0.9878	24.00	8.21E-02	
Clepo 204	6-28-89	Ni-S	409	8.90	1.438	1.000	0.063	20.11	24.1868	24.1740	0.0128	1.00	2.82E-02	2.97E-02
Clepo 204	6-28-89	Ni-S	513	8.90	1.531	1.000	0.063	21.40	24.4612	21.4461	0.0151	1.00	3.12E-02	
Clepo 204	6-28-89	Ni-P	144	8.90	1.500	1.000	0.063	20.97	18.7599	18.7455	0.0144	1.00	3.04E-02	3.19E-02
Clepo 204	6-28-89	Ni-P	166	8.90	1.438	1.000	0.063	20.11	18.8626	18.8474	0.0152	1.00	3.34E-02	
140 deg. F	Fresh Solution	Small Tank	pH 12.5	(only 5 lbs Clepo 204-T)										
Clepo 204	6-29-89	410	192	7.70	1.469	1.000	0.063	20.54	17.6750	17.6835	-0.0085	24.00	-8.82E-04	-1.15E-03
Clepo 204	6-29-89	410	191	7.70	1.375	1.000	0.063	19.25	18.7830	18.7958	-0.0128	24.00	-1.42E-03	
Clepo 204	6-29-89	C4340	127	7.84	1.438	1.000	0.063	20.11	14.7105	14.7194	-0.0089	24.00	-9.26E-04	-1.26E-03
Clepo 204	6-29-89	C4340	129	7.84	1.375	1.000	0.063	19.25	14.9713	14.9859	-0.0146	24.00	-1.59E-03	
Clepo 204	6-29-89	D6AC	48	8.20	1.469	1.000	0.094	21.33	17.4672	17.4847	-0.0175	24.00	-1.64E-03	-1.96E-03
Clepo 204	6-29-89	D6AC	51	8.20	1.344	1.000	0.094	19.57	20.7770	20.7992	-0.0222	24.00	-2.27E-03	
Clepo 204	6-29-89	321	13	7.92	1.469	1.000	0.063	20.54	14.8956	14.9070	-0.0114	24.00	-1.15E-03	-9.83E-04
Clepo 204	6-29-89	321	18	7.92	1.469	1.000	0.063	20.54	14.8512	14.8593	-0.0081	24.00	-8.17E-04	
Clepo 204	6-29-89	I-718	94	8.60	1.469	1.000	0.063	20.54	16.0561	16.0634	-0.0073	24.00	-6.78E-04	-5.04E-04
Clepo 204	6-29-89	I-718	95	8.60	1.406	1.000	0.063	19.68	16.2599	16.2633	-0.0034	24.00	-3.30E-04	
Clepo 204	6-29-89	HA 188	66	9.70	1.469	1.000	0.063	20.54	17.0341	17.0456	-0.0115	24.00	-9.47E-04	-9.21E-04
Clepo 204	6-29-89	HA 188	67	9.70	1.375	1.000	0.063	19.25	17.1740	17.1842	-0.0102	24.00	-8.96E-04	
Clepo 204	6-29-89	Cu	121	8.92	1.438	1.000	0.125	21.67	28.2627	26.9975	1.2652	24.00	1.07E-01	1.10E-01
Clepo 204	6-29-89	Cu	124	8.92	1.375	1.000	0.125	20.77	27.4839	26.2035	1.2804	24.00	1.13E-01	
Clepo 204	6-29-89	Ni-S	401	8.90	1.500	1.000	0.063	20.97	23.1842	23.1723	0.0119	1.00	2.51E-02	2.68E-02
Clepo 204	6-29-89	Ni-S	449	8.90	1.469	1.000	0.063	20.54	25.5229	25.5097	0.0132	1.00	2.84E-02	
Clepo 204	6-29-89	Ni-P	112	8.90	1.406	1.000	0.063	19.68	18.9130	18.9061	0.0069	1.00	1.55E-02	1.60E-02
Clepo 204	6-29-89	Ni-P	148	8.90	1.438	1.000	0.063	20.11	18.8332	18.8257	0.0075	1.00	1.65E-02	
140 deg. F	Small Tank	pH 10.72	Loaded with 1.0 oz/gal nickel											
Clepo 204	6-26-89	410	14	7.70	1.469	1.000	0.063	20.54	17.4670	17.4670	0.0000	24.00	0.00E+00	1.56E-05
Clepo 204	6-26-89	410	18	7.70	1.469	1.000	0.063	20.54	17.9551	17.9548	0.0003	24.00	3.11E-05	
Clepo 204	6-26-89	C4340	142	7.84	1.500	1.000	0.063	20.97	15.0370	15.0363	0.0007	24.00	6.99E-05	4.49E-05
Clepo 204	6-26-89	C4340	150	7.84	1.500	1.000	0.063	20.97	14.7005	14.7003	0.0002	24.00	2.00E-05	
Clepo 204	6-26-89	D6AC	6	8.20	1.469	1.000	0.094	21.34	20.0593	20.0588	0.0005	24.00	4.69E-05	5.62E-05
Clepo 204	6-26-89	D6AC	4	8.20	1.469	1.000	0.094	21.34	18.0544	18.0537	0.0007	24.00	6.56E-05	
Clepo 204	6-26-89	321	6	7.92	1.500	1.000	0.063	20.97	14.9557	14.9557	0.0000	24.00	0.00E+00	0.00E+00
Clepo 204	6-26-89	321	8	7.92	1.469	1.000	0.063	20.54	14.8811	14.8811	0.0000	24.00	0.00E+00	
Clepo 204	6-26-89	I-718	65	8.60	1.531	1.000	0.063	21.40	15.0512	15.0509	0.0003	24.00	2.67E-05	8.73E-06
Clepo 204	6-26-89	I-718	150	8.60	1.469	1.000	0.063	20.54	16.3915	16.3916	-0.0001	24.00	-9.29E-06	
Clepo 204	6-26-89	HA 188	52	9.70	1.500	1.000	0.063	20.97	17.0722	17.0721	0.0001	24.00	8.07E-06	1.15E-05

Stripper	Test Date	Coupon Material	Coupon #	Density (g/cm3)	Unmasked Dimensions in inches length	width	thick	Surface Area (cm2)	Initial Mass (grams)	Final Mass (grams)	Change Mass (grams)	Total Time (hours)	Stripping Rate (mil/hour)	Average S.R. (mil/hour)
Clepo 204	6-26-89	HA 188	12	9.70	1.500	1.000	0.125	22.58	35.9807	35.9805	0.0002	24.00	1.50E-05	
Clepo 204	6-26-89	Cu	130	8.92	1.500	1.000	0.125	22.58	27.7046	25.9475	1.7571	24.00	1.43E-01	1.49E-01
Clepo 204	6-26-89	Cu	168	8.92	1.469	1.000	0.125	22.13	28.2533	26.3988	1.8545	24.00	1.54E-01	
Clepo 204	6-26-89	Ni-S	325	8.90	1.500	1.000	0.063	20.97	23.3806	22.3884	0.9922	1.00	2.09E+00	2.12E+00
Clepo 204	6-26-89	Ni-S	515	8.90	1.469	1.000	0.063	20.54	22.5641	21.5711	0.9930	1.00	2.14E+00	
Clepo 204	6-26-89	Ni-P	61	8.90	1.531	1.000	0.063	21.40	19.2559	19.0853	0.1706	1.00	3.53E-01	3.41E-01
Clepo 204	6-26-89	Ni-P	17	8.90	1.500	1.000	0.063	20.97	18.8283	18.6718	0.1565	1.00	3.30E-01	
140 deg. F	Small Tank	pH 11.0	Loaded with 1.0 oz/gal nickel											
Clepo 204	6-27-89	410	200	7.70	1.406	1.000	0.063	19.68	18.4451	18.4449	0.0002	24.00	2.16E-05	2.67E-05
Clepo 204	6-27-89	410	17	7.70	1.438	1.000	0.063	20.11	16.8741	16.8738	0.0003	24.00	3.18E-05	
Clepo 204	6-27-89	C4340	144	7.84	1.469	1.000	0.063	20.54	15.0348	15.0346	0.0002	24.00	2.04E-05	-1.53E-05
Clepo 204	6-27-89	C4340	143	7.84	1.469	1.000	0.063	20.54	14.5416	14.5421	-0.0005	24.00	-5.09E-05	
Clepo 204	6-27-89	D6AC	52	8.20	1.375	1.000	0.094	20.02	20.6478	20.6478	0.0000	24.00	0.00E+00	2.39E-05
Clepo 204	6-27-89	D6AC	8	8.20	1.438	1.000	0.094	20.90	21.1429	21.1424	0.0005	24.00	4.79E-05	
Clepo 204	6-27-89	321	3	7.92	1.469	1.000	0.063	20.54	14.8430	14.8430	0.0000	24.00	0.00E+00	-1.01E-05
Clepo 204	6-27-89	321	1	7.92	1.469	1.000	0.063	20.54	15.1401	15.1403	-0.0002	24.00	-2.02E-05	
Clepo 204	6-27-89	I-718	92	8.60	1.500	1.000	0.063	20.97	16.0516	16.0519	-0.0003	24.00	-2.73E-05	-8.95E-05
Clepo 204	6-27-89	I-718	93	8.60	1.438	1.000	0.063	20.11	16.2533	16.2549	-0.0016	24.00	-1.52E-04	
Clepo 204	6-27-89	HA 188	62	9.70	1.406	1.000	0.063	19.69	16.4931	16.4939	-0.0008	24.00	-6.87E-05	-4.28E-05
Clepo 204	6-27-89	HA 188	58	9.70	1.438	1.000	0.063	20.12	16.9138	16.9140	-0.0002	24.00	-1.68E-05	
Clepo 204	6-27-89	Cu	152	8.92	1.438	1.000	0.125	21.67	28.4793	26.9322	1.5471	24.00	1.31E-01	1.33E-01
Clepo 204	6-27-89	Cu	141	8.92	1.469	1.000	0.125	22.13	28.2399	26.6083	1.6316	24.00	1.36E-01	
Clepo 204	6-27-89	Ni-S	365	8.90	1.563	1.000	0.063	21.82	23.6108	23.3848	0.2263	1.00	4.59E-01	5.07E-01
Clepo 204	6-27-89	Ni-S	510	8.90	1.563	1.000	0.063	21.82	22.8583	22.5845	0.2738	1.00	5.55E-01	
Clepo 204	6-27-89	Ni-P	190	8.90	1.500	1.000	0.063	20.97	18.7613	18.6973	0.0640	1.00	1.35E-01	1.52E-01
Clepo 204	6-27-89	Ni-P	188	8.90	1.500	1.000	0.063	20.97	18.5066	18.4269	0.0797	1.00	1.68E-01	
140 deg. F	Small Tank	pH 11.5	Loaded with 1.0 oz/gal nickel											
Clepo 204	6-28-89	410	193	7.70	1.406	1.000	0.063	19.68	17.8409	17.8405	0.0004	24.00	4.33E-05	2.73E-05
Clepo 204	6-28-89	410	194	7.70	1.344	1.000	0.063	18.83	18.0527	18.0526	0.0001	24.00	1.13E-05	
Clepo 204	6-28-89	C4340	140	7.84	1.438	1.000	0.063	20.11	14.7658	14.7658	0.0000	24.00	0.00E+00	0.00E+00
Clepo 204	6-28-89	C4340	136	7.84	1.375	1.000	0.063	19.25	14.8018	14.8018	0.0000	24.00	0.00E+00	
Clepo 204	6-28-89	D6AC	54	8.20	1.438	1.000	0.094	20.90	19.2785	19.2779	0.0006	24.00	5.74E-05	6.09E-05
Clepo 204	6-28-89	D6AC	53	8.20	1.500	1.000	0.094	21.78	19.2117	19.2110	0.0007	24.00	6.43E-05	
Clepo 204	6-28-89	321	17	7.92	1.375	1.000	0.063	19.25	14.8357	14.8354	0.0003	24.00	3.23E-05	3.23E-05
Clepo 204	6-28-89	321	12	7.92	1.375	1.000	0.063	19.25	14.9307	14.9304	0.0003	24.00	3.23E-05	
Clepo 204	6-28-89	I-718	98	8.60	1.375	1.000	0.063	19.25	16.2406	16.2407	-0.0001	24.00	-9.91E-06	2.41E-05
Clepo 204	6-28-89	I-718	99	8.60	1.406	1.000	0.063	19.68	16.4993	16.4987	0.0006	24.00	5.81E-05	
Clepo 204	6-28-89	HA 188	63	9.70	1.344	1.000	0.063	18.84	16.6888	16.6888	0.0000	24.00	0.00E+00	0.00E+00
Clepo 204	6-28-89	HA 188	68	9.70	1.406	1.000	0.063	19.69	17.1234	17.1234	0.0000	24.00	0.00E+00	
Clepo 204	6-28-89	Cu	115	8.92	1.406	1.000	0.125	21.22	28.5262	27.1125	1.4137	24.00	1.23E-01	1.18E-01
Clepo 204	6-28-89	Cu	180	8.92	1.438	1.000	0.125	21.67	28.4532	27.1203	1.3329	24.00	1.13E-01	
Clepo 204	6-28-89	Ni-S	492	8.90	1.469	1.000	0.063	20.54	24.0505	23.9600	0.0905	1.00	1.95E-01	1.84E-01
Clepo 204	6-28-89	Ni-S	479	8.90	1.500	1.000	0.063	20.97	22.3614	22.2798	0.0816	1.00	1.72E-01	
Clepo 204	6-28-89	Ni-P	278	8.90	1.469	1.000	0.063	20.54	18.8517	18.8175	0.0342	1.00	7.37E-02	6.94E-02
Clepo 204	6-28-89	Ni-P	132	8.90	1.438	1.000	0.063	20.11	18.7881	18.7585	0.0296	1.00	6.51E-02	

Stripper	Test Date	Coupon Material	Coupon #	Density (g/cm3)	Unmasked Dimensions in inches: length	width	thick	Surface Area (cm2)	Initial Mass (grams)	Final Mass (grams)	Change Mass (grams)	Total Time (hours)	Stripping Rate (mil/hour)	Average S.R. (mil/hour)
140 deg. F	Small Tank	pH 12.0	Loaded with 1.0 oz/gal nickel											
Clepo 204	6-29-89	410	196	7.70	1.375	1.000	0.063	19.25	17.8607	17.8600	0.0007	24.00	7.75E-05	4.43E-05
Clepo 204	6-29-89	410	198	7.70	1.375	1.000	0.063	19.25	17.9280	17.9279	0.0001	24.00	1.11E-05	
Clepo 204	6-29-89	C4340	130	7.84	1.469	1.000	0.063	20.54	14.8803	14.8803	0.0000	24.00	0.00E+00	-1.53E-05
Clepo 204	6-29-89	C4340	137	7.84	1.469	1.000	0.063	20.54	14.7942	14.7945	-0.0003	24.00	-3.06E-05	
Clepo 204	6-29-89	D6AC	49	8.20	1.500	1.000	0.094	21.77	18.7050	18.7053	-0.0003	24.00	-2.76E-05	8.73E-06
Clepo 204	6-29-89	D6AC	50	8.20	1.531	1.000	0.094	22.22	19.4426	19.4421	0.0005	24.00	4.50E-05	
Clepo 204	6-29-89	321	10	7.92	1.375	1.000	0.063	19.25	14.9278	14.9276	0.0002	24.00	2.15E-05	1.08E-05
Clepo 204	6-29-89	321	15	7.92	1.469	1.000	0.063	20.54	14.8674	14.8674	0.0000	24.00	0.00E+00	
Clepo 204	6-29-89	I-718	136	8.60	1.438	1.000	0.063	20.11	15.9786	15.9788	-0.0002	24.00	-1.90E-05	-1.43E-05
Clepo 204	6-29-89	I-718	97	8.60	1.406	1.000	0.063	19.68	16.1254	16.1255	-0.0001	24.00	-9.69E-06	
Clepo 204	6-29-89	HA 188	60	9.70	1.438	1.000	0.063	20.11	17.2833	17.2834	-0.0001	24.00	-8.41E-06	-4.20E-06
Clepo 204	6-29-89	HA 188	61	9.70	1.406	1.000	0.063	19.68	16.6489	16.6489	0.0000	24.00	0.00E+00	
Clepo 204	6-29-89	Cu	142	8.92	1.375	1.000	0.125	20.77	27.6317	26.5461	1.0856	24.00	9.61E-02	9.50E-02
Clepo 204	6-29-89	Cu	109	8.92	1.406	1.000	0.125	21.22	27.8735	26.7902	1.0833	24.00	9.39E-02	
Clepo 204	6-29-89	Ni-S	467	8.90	1.438	1.000	0.063	20.11	24.2111	24.1562	0.0549	1.00	1.21E-01	1.15E-01
Clepo 204	6-29-89	Ni-S	501	8.90	1.406	1.000	0.063	19.68	24.1702	24.1212	0.0487	1.00	1.09E-01	
Clepo 204	6-29-89	Ni-P	223	8.90	1.500	1.000	0.063	20.97	18.6711	18.6562	0.0149	1.00	3.14E-02	3.00E-02
Clepo 204	6-29-89	Ni-P	173	8.90	1.375	1.000	0.063	19.25	18.8373	18.8249	0.0124	1.00	2.85E-02	
140 deg. F	Small Tank	pH 12.5	Loaded with 1.0 oz/gal nickel											
Clepo 204	7-10-89	410	97	7.70	1.469	1.000	0.063	20.54	18.0780	18.0764	0.0016	24.00	1.66E-04	2.68E-04
Clepo 204	7-10-89	410	98	7.70	1.438	1.000	0.063	20.11	17.8272	17.8237	0.0035	24.00	3.71E-04	
Clepo 204	7-10-89	C4340	131	7.84	1.469	1.000	0.063	20.54	14.8591	14.8620	-0.0029	24.00	-2.95E-04	-2.05E-04
Clepo 204	7-10-89	C4340	132	7.84	1.438	1.000	0.063	20.11	14.8995	14.9006	-0.0011	24.00	-1.14E-04	
Clepo 204	7-10-89	D6AC	16	8.20	1.563	1.000	0.094	22.66	17.0737	17.0744	-0.0007	24.00	-6.18E-05	-3.55E-05
Clepo 204	7-10-89	D6AC	17	8.20	1.500	1.000	0.094	21.77	18.6741	18.6742	-0.0001	24.00	-9.19E-06	
Clepo 204	7-10-89	321	22	7.92	1.500	1.000	0.063	20.97	14.9107	14.9108	-0.0001	24.00	-9.88E-06	-5.64E-05
Clepo 204	7-10-89	321	25	7.92	1.438	1.000	0.063	20.11	14.8440	14.8450	-0.0010	24.00	-1.03E-04	
Clepo 204	7-10-89	I-718	139	8.60	1.469	1.000	0.063	20.54	16.1375	16.1380	-0.0005	24.00	-4.64E-05	0.00E+00
Clepo 204	7-10-89	I-718	140	8.60	1.469	1.000	0.063	20.54	16.1064	16.1059	0.0005	24.00	4.64E-05	
Clepo 204	7-10-89	HA 188	69	9.70	1.469	1.000	0.063	20.54	17.1400	17.1402	-0.0002	24.00	-1.65E-05	1.60E-05
Clepo 204	7-10-89	HA 188	70	9.70	1.500	1.000	0.063	20.97	17.0881	17.0875	0.0006	24.00	4.84E-05	
Clepo 204	7-10-89	Cu	108	8.92	1.469	1.000	0.125	22.13	28.2721	27.0414	1.2307	24.00	1.02E-01	9.77E-02
Clepo 204	7-10-89	Cu	191	8.92	1.469	1.000	0.125	22.13	28.3398	27.2183	1.1215	24.00	9.32E-02	
Clepo 204	7-10-89	Ni-S	355	8.90	1.500	1.000	0.063	20.97	21.8568	21.8368	0.0200	1.00	4.22E-02	3.79E-02
Clepo 204	7-10-89	Ni-S	303	8.90	1.500	1.000	0.063	20.97	22.5762	22.5603	0.0159	1.00	3.35E-02	
Clepo 204	7-10-89	Ni-P	93	8.90	1.500	1.000	0.063	20.97	19.1611	19.1611	0.0000	1.00	0.00E+00	-4.31E-04
Clepo 204	7-10-89	Ni-P	73	8.90	1.469	1.000	0.063	20.54	18.8173	18.8177	-0.0004	1.00	-8.61E-04	
140 deg. F	Large Tank	Fresh Solution	pH 10.4											
Clepo 204	6-27-89	410	12	7.70	1.500	1.000	0.063	20.97	18.1952	18.1947	0.0005	1.00	1.22E-03	1.10E-03
Clepo 204	6-27-89	410	71	7.70	1.500	1.000	0.063	20.97	17.2851	17.2847	0.0004	1.00	9.75E-04	
Clepo 204	6-27-89	C4340	148	7.84	1.500	1.000	0.063	20.97	14.6907	14.6900	0.0007	1.00	1.68E-03	1.94E-03
Clepo 204	6-27-89	C4340	146	7.84	1.469	1.000	0.063	20.54	14.9087	14.9078	0.0009	1.00	2.20E-03	
Clepo 204	6-27-89	D6AC	14	8.20	1.500	1.000	0.125	22.58	29.8838	29.8823	0.0015	1.00	3.19E-03	2.55E-03

Stripper	Test Date	Coupon Material	Coupon #	Density (g/cm3)	Unmasked Dimensions in inches length	width	thick	Surface Area (cm2)	Initial Mass (grams)	Final Mass (grams)	Change Mass (grams)	Total Time (hours)	Stripping Rate (mil/hour)	Average S.R. (mil/hour)
Clepo 204	6-27-89	D6AC	1	8.20	1.563	1.000	0.094	22.66	16.1325	16.1316	0.0009	1.00	1.91E-03	
Clepo 204	6-27-89	321	9	7.92	1.438	1.000	0.063	20.11	14.9088	14.9082	0.0006	1.00	1.48E-03	9.89E-04
Clepo 204	6-27-89	321	90	7.92	1.438	1.000	0.063	20.11	19.1773	19.1771	0.0002	1.00	4.94E-04	
Clepo 204	6-27-89	I-718	145	8.60	1.469	1.000	0.063	20.54	16.0986	16.0982	0.0004	1.00	8.92E-04	7.80E-04
Clepo 204	6-27-89	I-718	147	8.60	1.469	1.000	0.063	20.54	16.1336	16.1333	0.0003	1.00	6.69E-04	
Clepo 204	6-27-89	HA 188	55	9.70	1.438	1.000	0.063	20.11	16.6958	16.6953	0.0005	1.00	1.01E-03	1.01E-03
Clepo 204	6-27-89	HA 188	53	9.70	1.438	1.000	0.063	20.12	17.0261	17.0256	0.0005	1.00	1.01E-03	
Clepo 204	6-27-89	Cu	185	8.92	1.469	1.000	0.125	22.13	27.4862	27.4207	0.0655	1.00	1.31E-01	1.38E-01
Clepo 204	6-27-89	Cu	196	8.92	1.469	1.000	0.125	22.13	28.7248	28.6522	0.0726	1.00	1.45E-01	
Clepo 204	6-27-89	Ni-S	441	8.90	1.563	1.000	0.063	21.82	28.4225	27.9609	0.4616	0.50	1.87E+00	2.01E+00
Clepo 204	6-27-89	Ni-S	587	8.90	1.500	1.000	0.063	20.97	24.7540	24.2455	0.5085	0.50	2.15E+00	
Clepo 204	6-27-89	Ni-P	81	8.90	1.500	1.000	0.063	20.97	19.1047	19.0830	0.0217	0.50	9.16E-02	9.01E-02
Clepo 204	6-27-89	Ni-P	66	8.90	1.500	1.000	0.063	20.97	18.9641	18.9431	0.0210	0.50	8.86E-02	
140 deg. F	Large Tank	Fresh Solution	pH 10.4											
Clepo 204	6-27-89	410	16	7.70	1.500	1.000	0.063	20.97	17.8664	17.8665	-0.0001	4.00	-6.10E-05	0.00E+00
Clepo 204	6-27-89	410	18	7.70	1.500	1.000	0.063	20.97	17.8514	17.8513	0.0001	4.00	6.10E-05	
Clepo 204	6-27-89	C4340	149	7.84	1.500	1.000	0.063	20.97	15.0538	15.0534	0.0004	4.00	2.39E-04	2.08E-04
Clepo 204	6-27-89	C4340	147	7.84	1.531	1.000	0.063	21.40	15.2522	15.2519	0.0003	4.00	1.76E-04	
Clepo 204	6-27-89	D6AC	13	8.20	1.469	1.000	0.125	22.13	30.0716	30.0712	0.0004	4.00	2.17E-04	1.91E-04
Clepo 204	6-27-89	D6AC	3	8.20	1.500	1.000	0.094	21.78	20.2988	20.2985	0.0003	4.00	1.65E-04	
Clepo 204	6-27-89	321	81	7.92	1.469	1.000	0.063	20.54	18.8794	18.8792	0.0002	4.00	1.21E-04	3.03E-05
Clepo 204	6-27-89	321	5	7.92	1.469	1.000	0.063	20.54	14.9766	14.9767	-0.0001	4.00	-6.05E-05	
Clepo 204	6-27-89	I-718	146	8.60	1.438	1.000	0.063	20.11	16.1630	16.1627	0.0003	4.00	1.71E-04	2.49E-04
Clepo 204	6-27-89	I-718	149	8.60	1.500	1.000	0.063	20.97	16.2243	16.2237	0.0006	4.00	3.27E-04	
Clepo 204	6-27-89	HA 188	54	9.70	1.500	1.000	0.063	20.98	17.4763	17.4765	-0.0002	4.00	-9.67E-05	-4.84E-05
Clepo 204	6-27-89	HA 188	56	9.70	1.500	1.000	0.063	20.98	16.9377	16.9337	0.0000	4.00	0.00E+00	
Clepo 204	6-27-89	Cu	113	8.92	1.469	1.000	0.125	22.13	28.4566	28.1043	0.3523	4.00	1.76E-01	1.73E-01
Clepo 204	6-27-89	Cu	105	8.92	1.469	1.000	0.125	22.13	28.2544	27.9115	0.3429	4.00	1.71E-01	
Clepo 204	6-23-89	Ni-S	504	8.90	1.500	1.000	0.063	20.97	29.3110	28.0650	1.2460	1.00	2.63E+00	2.45E+00
Clepo 204	6-23-89	Ni-S	322	8.90	1.469	1.000	0.063	20.54	21.7272	20.6747	1.0525	1.00	2.27E+00	
Clepo 204	6-23-89	Ni-P	176	8.90	1.469	1.000	0.063	20.54	18.7462	18.5333	0.2129	1.00	4.59E-01	4.17E-01
Clepo 204	6-23-89	Ni-P	26	8.90	1.500	1.000	0.063	20.97	18.5914	18.4133	0.1781	1.00	3.76E-01	
140 deg. F	Large Tank	Fresh Solution	pH 10.4											
Clepo 204	6-27-89	410	13	7.70	1.406	1.000	0.063	19.68	18.0512	18.0501	0.0011	8.00	3.57E-04	3.81E-04
Clepo 204	6-27-89	410	11	7.70	1.469	1.000	0.063	20.54	17.7648	17.7635	0.0013	8.00	4.05E-04	
Clepo 204	6-27-89	C4340	53	7.84	1.500	1.000	0.063	20.97	14.8442	14.8431	0.0011	8.00	3.29E-04	3.21E-04
Clepo 204	6-27-89	C4340	145	7.84	1.438	1.000	0.063	20.11	14.9020	14.9010	0.0010	8.00	3.12E-04	
Clepo 204	6-27-89	D6AC	2	8.20	1.500	1.000	0.094	21.78	20.4218	20.4206	0.0012	8.00	3.31E-04	3.68E-04
Clepo 204	6-27-89	D6AC	5	8.20	1.531	1.000	0.094	22.22	16.5272	16.5257	0.0015	8.00	4.05E-04	
Clepo 204	6-27-89	321	7	7.92	1.469	1.000	0.063	20.54	14.8990	14.8988	0.0002	8.00	6.05E-05	1.82E-04
Clepo 204	6-27-89	321	4	7.92	1.469	1.000	0.063	20.54	14.8091	14.8081	0.0010	8.00	3.03E-04	
Clepo 204	6-27-89	I-718	67	8.60	1.438	1.000	0.063	20.11	15.3988	15.3983	0.0005	8.00	1.42E-04	2.49E-04
Clepo 204	6-27-89	I-718	148	8.60	1.500	1.000	0.063	20.97	16.2509	16.2496	0.0013	8.00	3.55E-04	
Clepo 204	6-27-89	HA 188	51	9.70	1.469	1.000	0.063	20.55	16.7105	16.7102	0.0003	8.00	7.41E-05	1.04E-04
Clepo 204	6-27-89	HA 188	11	9.70	1.500	1.000	0.125	22.58	35.9924	35.9918	0.0006	8.00	1.35E-04	

Stripper	Test Date	Coupon Material	Coupon #	Density (g/cm3)	Unmasked Dimensions in inches length	width	thick	Surface Area (cm2)	Initial Mass (grams)	Final Mass (grams)	Change Mass (grams)	Total Time (hours)	Stripping Rate (mil/hour)	Average S.R. (mil/hour)
Clepo 204	6-27-89	Cu	148	8.92	1.438	1.000	0.125	21.67	27.6505	27.2151	0.4354	8.00	1.11E-01	1.34E-01
Clepo 204	6-27-89	Cu	198	8.92	1.469	1.000	0.125	22.13	28.1588	27.5298	0.6290	8.00	1.57E-01	
Clepo 204	6-27-89	Ni-S	373	8.90	1.500	1.000	0.063	20.97	21.2774	19.5209	1.7565	2.00	1.85E+00	1.80E+00
Clepo 204	6-27-89	Ni-S	378	8.90	1.375	1.000	0.063	19.25	22.4400	20.5978	1.5162	2.00	1.74E+00	
Clepo 204	6-27-89	Ni-P	19	8.90	1.500	1.000	0.063	20.97	19.0367	18.6241	0.4126	2.00	4.35E-01	4.74E-01
Clepo 204	6-27-89	Ni-P	289	8.90	1.469	1.000	0.063	20.54	18.8148	18.3388	0.4760	2.00	5.13E-01	
140 deg. F	Large Tank	Fresh Solution	pH 10.4											
Clepo 204	6-23-89	410	73	7.70	1.500	1.000	0.063	20.97	17.2656	17.2660	-0.0004	24.00	-4.06E-05	-2.03E-05
Clepo 204	6-23-89	410	74	7.70	1.500	1.000	0.063	20.97	17.5362	17.5362	0.0000	24.00	0.00E+00	
Clepo 204	6-23-89	C4340	55	7.84	1.500	1.000	0.063	20.97	14.9177	14.9176	0.0001	24.00	9.98E-06	-2.28E-05
Clepo 204	6-23-89	C4340	56	7.84	1.344	1.000	0.063	18.83	14.8380	14.8385	-0.0005	24.00	-5.56E-05	
Clepo 204	6-23-89	D6AC	16	8.20	1.500	1.000	0.094	21.77	29.6652	29.6649	0.0003	24.00	2.76E-05	1.38E-05
Clepo 204	6-23-89	D6AC	15	8.20	1.344	1.000	0.094	19.57	29.8296	29.8296	0.0000	24.00	0.00E+00	
Clepo 204	6-23-89	321	82	7.92	1.438	1.000	0.063	20.11	18.9668	18.9672	-0.0004	24.00	-4.12E-05	-4.63E-05
Clepo 204	6-23-89	321	89	7.92	1.438	1.000	0.063	20.11	19.0290	19.0295	-0.0005	24.00	-5.15E-05	
Clepo 204	6-23-89	I-718	61	8.60	1.438	1.000	0.063	20.11	15.5753	15.5762	-0.0009	24.00	-8.54E-05	-7.11E-05
Clepo 204	6-23-89	I-718	62	8.60	1.438	1.000	0.063	20.11	15.5720	15.5726	-0.0006	24.00	-5.69E-05	
Clepo 204	6-23-89	HA 188	15	9.70	1.469	1.000	0.063	20.54	35.8270	35.8275	-0.0005	24.00	-4.12E-05	-2.47E-05
Clepo 204	6-23-89	HA 188	13	9.70	1.469	1.000	0.063	20.54	35.9979	35.9980	-0.0001	24.00	-8.23E-06	
Clepo 204	6-23-89	Cu	166	8.92	1.500	1.000	0.125	22.58	27.8845	25.3797	2.5048	24.00	2.04E-01	2.11E-01
Clepo 204	6-23-89	Cu	195	8.92	1.469	1.000	0.125	22.13	28.3111	25.6824	2.6287	24.00	2.18E-01	
Clepo 204	6-27-89	Ni-S	334	8.90	1.500	1.000	0.063	20.97	21.7730	19.0958	2.6772	4.00	1.41E+00	1.46E+00
Clepo 204	6-27-89	Ni-S	339	8.90	1.469	1.000	0.063	20.54	22.9943	20.2990	2.7844	4.00	1.50E+00	
Clepo 204	6-27-89	Ni-P	119	8.90	1.500	1.000	0.063	20.97	18.7679	18.2353	0.5326	4.00	2.81E-01	3.09E-01
Clepo 204	6-27-89	Ni-P	149	8.90	1.500	1.000	0.063	20.97	18.7359	18.0973	0.6386	4.00	3.37E-01	
140 deg. F	Large Tank	Fresh Solution	pH 10.37	Loaded with 1.0 oz/gal nickel	AA sample: dil. 1/5000 conc. 1.53									
Clepo 204	7-13-89	410	94	7.70	1.375	1.000	0.063	19.25	17.2684	17.2683	0.0001	1.00	2.66E-04	3.82E-04
Clepo 204	7-13-89	410	100	7.70	1.469	1.000	0.063	20.54	16.7086	17.7084	0.0002	1.00	4.98E-04	
Clepo 204	7-13-89	C4340	125	7.84	1.344	1.000	0.063	18.83	14.7390	14.7387	0.0003	1.00	8.00E-04	5.31E-04
Clepo 204	7-13-89	C4340	123	7.84	1.375	1.000	0.063	19.25	15.2784	15.2783	0.0001	1.00	2.61E-04	
Clepo 204	7-13-89	D6AC	26	8.20	1.531	1.000	0.094	22.22	17.5944	17.5941	0.0003	1.00	6.48E-04	4.37E-04
Clepo 204	7-13-89	D6AC	27	8.20	1.469	1.000	0.094	21.34	20.5353	20.5352	0.0001	1.00	2.25E-04	
Clepo 204	7-13-89	321	32	7.92	1.469	1.000	0.063	20.54	14.4709	14.4709	0.0000	1.00	0.00E+00	1.19E-04
Clepo 204	7-13-89	321	33	7.92	1.500	1.000	0.063	20.97	15.0976	15.0975	0.0001	1.00	2.37E-04	
Clepo 204	7-13-89	I-718	135	8.60	1.469	1.000	0.063	20.54	16.0289	16.0289	0.0000	1.00	0.00E+00	2.18E-04
Clepo 204	7-13-89	I-718	133	8.60	1.500	1.000	0.063	20.97	16.2458	16.2456	0.0002	1.00	4.37E-04	
Clepo 204	7-13-89	HA 188	75	9.70	1.438	1.000	0.063	20.11	17.3627	17.3628	-0.0001	1.00	-2.02E-04	-4.88E-04
Clepo 204	7-13-89	HA 188	77	9.70	1.500	1.000	0.063	20.98	17.2801	17.2805	-0.0004	1.00	-7.74E-04	
Clepo 204	7-13-89	Cu	138	8.92	1.469	1.000	0.125	22.13	27.6817	27.6631	0.0186	1.00	3.71E-02	3.55E-02
Clepo 204	7-13-89	Cu	196	8.92	1.500	1.000	0.125	22.58	28.6508	28.6335	0.0173	1.00	3.38E-02	
Clepo 204	7-13-89	Ni-S	367	8.90	1.500	1.000	0.063	20.97	23.9605	23.7170	0.2435	0.50	1.03E+00	1.11E+00
Clepo 204	7-13-89	Ni-S	319	8.90	1.531	1.000	0.063	21.40	25.4927	25.2055	0.2872	0.50	1.19E+00	
Clepo 204	7-13-89	Ni-P	103	8.90	1.531	1.000	0.063	21.40	18.4443	18.4316	0.0127	0.50	5.25E-02	5.20E-02
Clepo 204	7-13-89	Ni-P	60	8.90	1.500	1.000	0.063	20.97	18.6581	18.6459	0.0122	0.50	5.15E-02	

Stripper	Test Date	Coupon Material	Coupon #	Density (g/cm3)	Unmasked Dimensions in inches length	width	thick	Surface Area (cm2)	Initial Mass (grams)	Final Mass (grams)	Change Mass (grams)	Total Time (hours)	Stripping Rate (mil/hour)	Average S.R. (mil/hour)
140 deg. F	Large Tank	Fresh Solution	pH 10.37	Loaded with 1.0 oz/gal nickel										
Clepo 204	7-13-89	410	91	7.70	1.438	1.000	0.063	20.11	17.2541	17.2543	-0.0002	4.00	-1.27E-04	-1.25E-04
Clepo 204	7-13-89	410	199	7.70	1.500	1.000	0.063	20.97	18.0738	18.0740	-0.0002	4.00	-1.22E-04	
Clepo 204	7-13-89	C4340	121	7.84	1.500	1.000	0.063	20.97	14.6682	14.6682	0.0000	4.00	0.00E+00	-1.25E-04
Clepo 204	7-13-89	C4340	119	7.84	1.438	1.000	0.063	20.11	14.9480	14.9484	-0.0004	4.00	-2.50E-04	
Clepo 204	7-13-89	D6AC	22	8.20	1.500	1.000	0.094	21.78	17.0813	17.0821	-0.0008	4.00	-4.41E-04	-2.20E-04
Clepo 204	7-13-89	D6AC	23	8.20	1.500	1.000	0.094	21.78	20.1948	20.1948	0.0000	4.00	0.00E+00	
Clepo 204	7-13-89	321	34	7.92	1.500	1.000	0.063	20.97	14.9071	14.9075	-0.0004	4.00	-2.37E-04	-2.96E-04
Clepo 204	7-13-89	321	36	7.92	1.500	1.000	0.063	20.97	15.0038	15.0044	-0.0006	4.00	-3.56E-04	
Clepo 204	7-13-89	I-718	130	8.60	1.531	1.000	0.063	21.40	15.8791	15.8794	-0.0003	4.00	-1.60E-04	-3.26E-04
Clepo 204	7-13-89	I-718	132	8.60	1.500	1.000	0.063	20.97	15.9841	15.9850	-0.0009	4.00	-4.91E-04	
Clepo 204	7-13-89	HA 188	80	9.70	1.500	1.000	0.063	20.98	17.0972	17.0973	-0.0001	4.00	-4.84E-05	5.04E-07
Clepo 204	7-13-89	HA 188	72	9.70	1.469	1.000	0.063	20.55	16.6087	16.6086	0.0001	4.00	4.94E-05	
Clepo 204	7-13-89	Cu	103	8.92	1.500	1.000	0.125	22.58	28.5004	28.3511	0.1493	4.00	7.30E-02	6.87E-02
Clepo 204	7-13-89	Cu	185	8.92	1.469	1.000	0.125	22.13	27.4199	27.2907	0.1292	4.00	6.44E-02	
Clepo 204	7-13-89	Ni-S	569	8.90	1.500	1.000	0.063	20.97	22.3137	21.7926	0.5211	1.00	1.10E+00	1.07E+00
Clepo 204	7-13-89	Ni-S	428	8.90	1.500	1.000	0.063	20.97	23.4400	22.9451	0.4949	1.00	1.04E+00	
Clepo 204	7-13-89	Ni-P	15	8.90	1.500	1.000	0.063	20.97	18.8125	18.7970	0.0155	1.00	3.27E-02	3.41E-02
Clepo 204	7-13-89	Ni-P	118	8.90	1.469	1.000	0.063	20.54	18.7440	18.7275	0.0165	1.00	3.55E-02	
140 deg. F	Large Tank	Fresh Solution	pH 10.37	Loaded with 1.0 oz/gal nickel										
Clepo 204	7-13-89	410	92	7.70	1.500	1.000	0.063	20.97	17.4392	17.4391	0.0001	8.00	3.05E-05	3.22E-05
Clepo 204	7-13-89	410	93	7.70	1.344	1.000	0.063	18.83	17.4732	17.4731	0.0001	8.00	3.39E-05	
Clepo 204	7-13-89	C4340	124	7.84	1.469	1.000	0.063	20.54	15.1687	15.1685	0.0002	8.00	6.11E-05	1.56E-05
Clepo 204	7-13-89	C4340	118	7.84	1.500	1.000	0.063	20.97	14.9341	14.9342	-0.0001	8.00	-2.99E-05	
Clepo 204	7-13-89	D6AC	25	8.20	1.563	1.000	0.094	22.66	17.3740	17.3736	0.0004	8.00	1.06E-04	1.47E-04
Clepo 204	7-13-89	D6AC	20	8.20	1.531	1.000	0.094	22.22	17.4892	17.4885	0.0007	8.00	1.89E-04	
Clepo 204	7-13-89	321	31	7.92	1.500	1.000	0.063	20.97	14.9108	14.9104	0.0004	8.00	1.19E-04	8.95E-05
Clepo 204	7-13-89	321	30	7.92	1.469	1.000	0.063	20.54	14.9296	14.9294	0.0002	8.00	6.05E-05	
Clepo 204	7-13-89	I-718	128	8.60	1.469	1.000	0.063	20.54	16.2459	16.2457	0.0002	8.00	5.57E-05	1.39E-05
Clepo 204	7-13-89	I-718	131	8.60	1.469	1.000	0.063	20.54	15.8580	15.8581	-0.0001	8.00	-2.79E-05	
Clepo 204	7-13-89	HA 188	74	9.70	1.500	1.000	0.063	20.98	17.4180	17.4178	0.0002	8.00	4.84E-05	3.56E-05
Clepo 204	7-13-89	HA 188	73	9.70	1.469	1.000	0.125	22.13	17.3523	17.3522	0.0001	8.00	2.29E-05	
Clepo 204	7-13-89	Cu	117	8.92	1.469	1.000	0.125	22.13	27.6306	27.3802	0.2504	8.00	6.24E-02	8.10E-02
Clepo 204	7-13-89	Cu	156	8.92	1.469	1.000	0.125	22.13	28.2599	27.8603	0.3996	8.00	9.96E-02	
Clepo 204	7-13-89	Ni-S	491	8.90	1.531	1.000	0.063	21.40	23.1244	22.4243	0.7001	2.00	7.24E-01	9.92E-01
Clepo 204	7-13-89	Ni-S	465	8.90	1.531	1.000	0.063	21.40	25.3293	24.1101	1.2192	2.00	1.26E+00	
Clepo 204	7-13-89	Ni-P	69	8.90	1.500	1.000	0.063	20.97	19.0207	18.9264	0.0943	2.00	9.95E-02	6.79E-02
Clepo 204	7-13-89	Ni-P	113	8.90	1.500	1.000	0.063	20.97	19.0300	18.9956	0.0344	2.00	3.63E-02	
140 deg. F	Large Tank	Fresh Solution	pH 10.37	Loaded with 1.0 oz/gal nickel										
Clepo 204	7-13-89	410	96	7.70	1.344	1.000	0.063	18.83	17.8808	17.8804	0.0004	24.00	4.53E-05	4.86E-05
Clepo 204	7-13-89	410	95	7.70	1.469	1.000	0.063	20.54	17.2724	17.2719	0.0005	24.00	5.19E-05	
Clepo 204	7-13-89	C4340	122	7.84	1.469	1.000	0.063	20.54	14.9174	14.9173	0.0001	24.00	1.02E-05	4.07E-05
Clepo 204	7-13-89	C4340	126	7.84	1.469	1.000	0.063	20.54	14.6874	14.6867	0.0007	24.00	7.13E-05	
Clepo 204	7-13-89	D6AC	24	8.20	1.500	1.000	0.094	21.77	17.1429	17.1426	0.0003	24.00	2.76E-05	3.25E-05

Stripper	Test Date	Coupon Material	Coupon #	Density (g/cm3)	Unmasked Dimensions in inches length	width	thick	Surface Area (cm2)	Initial Mass (grams)	Final Mass (grams)	Change Mass (grams)	Total Time (hours)	Stripping Rate (mil/hour)	Average S.R. (mil/hour)
Clepo 204	7-13-89	D6AC	21	8.20	1.469	1.000	0.094	21.33	19.3123	19.3119	0.0004	24.00	3.75E-05	
Clepo 204	7-13-89	321	29	7.92	1.469	1.000	0.063	20.54	14.9808	14.9804	0.0004	24.00	4.03E-05	3.03E-05
Clepo 204	7-13-89	321	35	7.92	1.469	1.000	0.063	20.54	14.6721	14.6719	0.0002	24.00	2.02E-05	
Clepo 204	7-13-89	I-718	129	8.60	1.469	1.000	0.063	20.54	15.9247	15.9246	0.0001	24.00	9.29E-06	1.41E-05
Clepo 204	7-13-89	I-718	134	8.60	1.438	1.000	0.063	20.11	16.1134	16.1132	0.0002	24.00	1.90E-05	
Clepo 204	7-13-89	HA 188	71	9.70	1.469	1.000	0.063	20.54	16.6346	16.6346	0.0000	24.00	0.00E+00	4.12E-06
Clepo 204	7-13-89	HA 188	76	9.70	1.469	1.000	0.063	20.54	17.3828	17.3827	0.0001	24.00	8.23E-06	
Clepo 204	7-13-89	Cu	158	8.92	1.438	1.000	0.125	21.67	28.8137	27.3991	1.4146	24.00	1.20E-01	1.19E-01
Clepo 204	7-13-89	Cu	200	8.92	1.344	1.000	0.125	20.31	27.6750	26.3629	1.3121	24.00	1.19E-01	
Clepo 204	7-13-89	Ni-S	362	8.90	1.500	1.000	0.063	20.97	23.2750	20.9868	2.2882	4.00	1.21E+00	1.12E+00
Clepo 204	7-13-89	Ni-S	556	8.90	1.531	1.000	0.063	21.40	21.4888	19.5035	1.9853	4.00	1.03E+00	
Clepo 204	7-13-89	Ni-P	39	8.90	1.500	1.000	0.063	20.97	19.1037	18.7562	0.3475	4.00	1.83E-01	1.65E-01
Clepo 204	7-13-89	Ni-P	263	8.90	1.500	1.000	0.063	20.97	18.7402	18.4604	0.2798	4.00	1.48E-01	

140 deg. F Large Tank Fresh Solution pH 10.2 Loaded with 1.0 oz/gal nickel Rejuvinated with 12.5 lbs Clepo 204-T

Stripper	Test Date	Coupon Material	Coupon #	Density (g/cm3)	length	width	thick	Surface Area (cm2)	Initial Mass (grams)	Final Mass (grams)	Change Mass (grams)	Total Time (hours)	Stripping Rate (mil/hour)	Average S.R. (mil/hour)
Clepo 204	7-21-89	410	176	7.70	1.438	1.000	0.063	20.11	17.8626	17.8614	0.0012	1.00	3.05E-03	1.78E-03
Clepo 204	7-21-89	410	177	7.70	1.438	1.000	0.063	20.11	17.7246	17.7244	0.0002	1.00	5.08E-04	
Clepo 204	7-21-89	C4340	133	7.84	1.406	1.000	0.063	19.68	15.0379	15.0373	0.0006	1.00	1.53E-03	1.72E-03
Clepo 204	7-21-89	C4340	134	7.84	1.500	1.000	0.063	20.97	14.8982	14.8974	0.0008	1.00	1.92E-03	
Clepo 204	7-21-89	D6AC	12	8.20	1.500	1.000	0.094	21.78	20.0313	20.0303	0.0010	1.00	2.20E-03	1.75E-03
Clepo 204	7-21-89	D6AC	19	8.20	1.531	1.000	0.094	22.22	19.7607	19.7601	0.0006	1.00	1.30E-03	
Clepo 204	7-21-89	321	24	7.92	1.438	1.000	0.063	20.11	15.0227	15.0222	0.0005	1.00	1.24E-03	4.94E-04
Clepo 204	7-21-89	321	21	7.92	1.438	1.000	0.063	20.11	15.0365	15.0366	-0.0001	1.00	-2.47E-04	
Clepo 204	7-21-89	I-718	125	8.60	1.375	1.000	0.063	19.25	16.1354	16.1348	0.0006	1.00	1.43E-03	1.05E-03
Clepo 204	7-21-89	I-718	124	8.60	1.438	1.000	0.063	20.11	15.9701	15.9698	0.0003	1.00	6.83E-04	
Clepo 204	7-21-89	HA 188	78	9.70	1.438	1.000	0.063	20.11	17.4196	17.4196	0.0000	1.00	0.00E+00	1.05E-04
Clepo 204	7-21-89	HA 188	79	9.70	1.375	1.000	0.063	19.27	17.0861	17.0860	0.0001	1.00	2.11E-04	
Clepo 204	7-21-89	Cu	31	8.92	1.375	1.000	0.125	20.77	27.2100	27.1767	0.0333	1.00	7.08E-02	7.60E-02
Clepo 204	7-21-89	Cu	33	8.92	1.375	1.000	0.125	20.77	29.1580	29.1198	0.0382	1.00	8.12E-02	
Clepo 204	7-21-89	Ni-S	456	8.90	1.500	1.000	0.063	20.97	24.6172	24.5603	0.0569	0.50	2.40E-01	2.44E-01
Clepo 204	7-21-89	Ni-S	427	8.90	1.406	1.000	0.063	19.68	23.9892	23.9342	0.0550	0.50	2.47E-01	
Clepo 204	7-21-89	Ni-P	243	8.90	1.500	1.000	0.063	20.97	18.9382	18.9149	0.0233	0.50	9.83E-02	9.85E-02
Clepo 204	7-21-89	Ni-P	271	8.90	1.469	1.000	0.063	20.54	19.0476	19.0247	0.0229	0.50	9.86E-02	
Clepo 204	7-21-89	410	174	7.70	1.500	1.000	0.063	20.97	17.7966	17.7961	0.0005	4.00	3.05E-04	3.39E-04
Clepo 204	7-21-89	410	175	7.70	1.469	1.000	0.063	20.54	17.3869	17.3863	0.0006	4.00	3.73E-04	
Clepo 204	7-21-89	C4340	135	7.84	1.469	1.000	0.063	20.54	15.1563	15.1564	-0.0001	4.00	-6.11E-05	6.31E-05
Clepo 204	7-21-89	C4340	120	7.84	1.438	1.000	0.063	20.11	15.2825	15.2822	0.0003	4.00	1.87E-04	
Clepo 204	7-21-89	D6AC	11	8.20	1.500	1.000	0.094	21.78	17.2973	17.2966	0.0007	4.00	3.86E-04	3.90E-04
Clepo 204	7-21-89	D6AC	10	8.20	1.469	1.000	0.094	21.34	19.3492	19.3485	0.0007	4.00	3.94E-04	
Clepo 204	7-21-89	321	19	7.92	1.500	1.000	0.063	20.97	14.9646	14.9644	0.0002	4.00	1.19E-04	-3.87E-06
Clepo 204	7-21-89	321	27	7.92	1.406	1.000	0.063	19.68	14.8263	14.8265	-0.0002	4.00	-1.26E-04	
Clepo 204	7-21-89	I-718	126	8.60	1.406	1.000	0.063	19.68	16.0671	16.0673	-0.0002	4.00	-1.16E-04	8.12E-05
Clepo 204	7-21-89	I-718	127	8.60	1.469	1.000	0.063	20.54	16.3384	16.3379	0.0005	4.00	2.79E-04	
Clepo 204	7-21-89	HA 188	81	9.70	1.469	1.000	0.063	20.55	17.0754	17.0746	0.0008	4.00	3.95E-04	3.49E-04
Clepo 204	7-21-89	HA 188	82	9.70	1.438	1.000	0.063	20.12	16.8870	16.8864	0.0006	4.00	3.03E-04	
Clepo 204	7-21-89	Cu	86	8.92	1.406	1.000	0.125	21.22	28.1763	28.0216	0.1547	4.00	8.04E-02	7.95E-02
Clepo 204	7-21-89	Cu	92	8.92	1.375	1.000	0.125	20.77	28.8880	28.7402	0.1478	4.00	7.85E-02	
Clepo 204	7-21-89	Ni-S	314	8.90	1.469	1.000	0.063	20.54	22.3120	22.1802	0.1318	1.00	2.84E-01	2.59E-01

Stripper	Test Date	Coupon Material	Coupon #	Density (g/cm3)	Unmasked Dimensions in inches length	width	thick	Surface Area (cm2)	Initial Mass (grams)	Final Mass (grams)	Change Mass (grams)	Total Time (hours)	Stripping Rate (mil/hour)	Average S.R. (mil/hour)
Clepo 204	7-21-89	Ni-S	564	8.90	1.500	1.000	0.063	20.97	24.3299	24.2190	0.1109	1.00	2.34E-01	
Clepo 204	7-21-89	Ni-P	40	8.90	1.438	1.000	0.063	20.11	18.8417	18.8176	0.0241	1.00	5.30E-02	9.45E-02
Clepo 204	7-21-89	Ni-P	62	8.90	1.500	1.000	0.063	20.97	19.1956	19.1311	0.0645	1.00	1.36E-01	
Clepo 204	7-21-89	410	180	7.70	1.563	1.000	0.063	21.82	18.1215	18.1218	-0.0003	8.00	-8.79E-05	4.75E-05
Clepo 204	7-21-89	410	178	7.70	1.500	1.000	0.063	20.97	18.0030	18.0027	0.0006	8.00	1.83E-04	
Clepo 204	7-21-89	C4340	114	7.84	1.406	1.000	0.063	19.68	14.9305	14.9301	0.0004	8.00	1.28E-04	2.17E-04
Clepo 204	7-21-89	C4340	115	7.84	1.469	1.000	0.063	20.54	15.1310	15.1300	0.0010	8.00	3.06E-04	
Clepo 204	7-21-89	D6AC	15	8.20	1.469	1.000	0.094	21.34	17.8909	17.8909	0.0000	8.00	0.00E+00	6.89E-05
Clepo 204	7-21-89	D6AC	18	8.20	1.500	1.000	0.094	21.78	19.1332	19.1327	0.0005	8.00	1.38E-04	
Clepo 204	7-21-89	321	26	7.92	1.500	1.000	0.063	20.97	14.9149	14.9148	0.0001	8.00	2.96E-05	2.96E-05
Clepo 204	7-21-89	321	28	7.92	1.500	1.000	0.063	20.97	14.8202	14.8201	0.0001	8.00	2.96E-05	
Clepo 204	7-21-89	I-718	144	8.60	1.469	1.000	0.063	20.54	16.2009	16.2009	0.0000	8.00	0.00E+00	-1.36E-05
Clepo 204	7-21-89	I-718	141	8.60	1.500	1.000	0.063	20.97	16.1538	16.1539	-0.0001	8.00	-2.73E-05	
Clepo 204	7-21-89	HA 188	85	9.70	1.469	1.000	0.063	20.55	17.2189	17.2186	0.0003	8.00	7.41E-05	3.70E-05
Clepo 204	7-21-89	HA 188	86	9.70	1.438	1.000	0.125	21.67	16.9152	16.9452	0.0000	8.00	0.00E+00	
Clepo 204	7-21-89	Cu	1	8.92	1.438	1.000	0.125	21.67	29.1196	28.8056	0.3140	8.00	7.99E-02	7.93E-02
Clepo 204	7-21-89	Cu	29	8.92	1.438	1.000	0.125	21.67	28.8674	28.5585	0.3089	8.00	7.86E-02	
Clepo 204	7-21-89	Ni-S	552	8.90	1.438	1.000	0.063	20.11	22.8059	22.5260	0.2799	2.00	3.08E-01	3.15E-01
Clepo 204	7-21-89	Ni-S	576	8.90	1.438	1.000	0.063	20.11	21.5685	21.2763	0.2922	2.00	3.21E-01	
Clepo 204	7-21-89	Ni-P	29	8.90	1.375	1.000	0.063	19.25	18.8473	18.8071	0.0402	2.00	4.62E-02	5.00E-02
Clepo 204	7-21-89	Ni-P	57	8.90	1.500	1.000	0.063	20.97	18.8350	18.7840	0.0510	2.00	5.38E-02	
Clepo 204	7-21-89	410	173	7.70	1.469	1.000	0.063	20.54	18.0640	18.0636	0.0004	24.00	4.15E-05	4.24E-05
Clepo 204	7-21-89	410	179	7.70	1.406	1.000	0.063	19.68	17.9839	17.9835	0.0004	24.00	4.33E-05	
Clepo 204	7-21-89	C4340	117	7.84	1.500	1.000	0.063	20.97	14.8976	14.8976	0.0000	24.00	0.00E+00	1.02E-05
Clepo 204	7-21-89	C4340	116	7.84	1.469	1.000	0.063	20.54	15.2820	15.2818	0.0002	24.00	2.04E-05	
Clepo 204	7-21-89	D6AC	13	8.20	1.469	1.000	0.094	21.33	18.0343	18.0340	0.0003	24.00	2.81E-05	5.63E-05
Clepo 204	7-21-89	D6AC	14	8.20	1.469	1.000	0.094	21.33	21.0087	21.0078	0.0009	24.00	8.44E-05	
Clepo 204	7-21-89	321	20	7.92	1.438	1.000	0.063	20.11	15.0041	15.0036	0.0005	24.00	5.15E-05	3.07E-05
Clepo 204	7-21-89	321	23	7.92	1.500	1.000	0.063	20.97	14.7388	14.7387	0.0001	24.00	9.88E-06	
Clepo 204	7-21-89	I-718	142	8.60	1.438	1.000	0.063	20.11	16.1797	16.1798	-0.0001	24.00	-9.48E-06	-2.29E-05
Clepo 204	7-21-89	I-718	143	8.60	1.500	1.000	0.063	20.97	16.0703	16.0707	-0.0004	24.00	-3.64E-05	
Clepo 204	7-21-89	HA 188	83	9.70	1.500	1.000	0.063	20.97	16.8088	16.8089	-0.0001	24.00	-8.07E-06	2.07E-05
Clepo 204	7-21-89	HA 188	84	9.70	1.469	1.000	0.063	20.54	16.8302	16.8296	0.0006	24.00	4.94E-05	
Clepo 204	7-21-89	Cu	100	8.92	1.500	1.000	0.125	22.58	28.6598	27.3154	1.3444	24.00	1.09E-01	1.05E-01
Clepo 204	7-21-89	Cu	94	8.92	1.469	1.000	0.125	22.13	27.5523	26.3459	1.2064	24.00	1.00E-01	
Clepo 204	7-21-89	Ni-S	366	8.90	1.500	1.000	0.063	20.97	27.0315	25.8783	1.1532	4.00	6.08E-01	5.32E-01
Clepo 204	7-21-89	Ni-S	488	8.90	1.406	1.000	0.063	19.68	22.1984	21.3859	0.8125	4.00	4.57E-01	
Clepo 204	7-21-89	Ni-P	95	8.90	1.375	1.000	0.063	19.25	19.0976	18.9831	0.1145	4.00	6.58E-02	5.27E-02
Clepo 204	7-21-89	Ni-P	105	8.90	1.438	1.000	0.063	20.11	18.6044	18.5323	0.0721	4.00	3.96E-02	
140 deg. F	loaded with 3 oz/gal Nickel													
Clepo 204	6-20-89	410	79	7.70	1.531	1.000	0.063	21.40	17.5325	17.5324	0.0001	8.00	2.99E-05	-3.08E-05
Clepo 204	6-20-89	410	80	7.70	1.500	1.000	0.063	20.97	17.0948	17.0951	-0.0003	8.00	-9.14E-05	
Clepo 204	6-20-89	C4340	32	7.84	1.500	1.000	0.063	20.97	14.5994	14.5996	-0.0002	8.00	-5.99E-05	-2.99E-05
Clepo 204	6-20-89	C4340	52	7.84	1.500	1.000	0.063	20.97	15.0864	15.0864	0.0000	8.00	0.00E+00	
Clepo 204	6-20-89	D6AC	91	8.20	1.500	1.000	0.125	22.58	30.5247	30.5241	0.0006	8.00	1.59E-04	2.02E-04
Clepo 204	6-20-89	D6AC	92	8.20	1.469	1.000	0.125	22.13	30.7418	30.7409	0.0009	8.00	2.44E-04	
Clepo 204	6-20-89	321	85	7.92	1.531	1.000	0.063	21.40	18.8437	18.8436	0.0001	8.00	2.90E-05	-5.96E-05

Stripper	Test Date	Coupon Material	Coupon #	Density (g/cm3)	Unmasked Dimensions in inches length	width	thick	Surface Area (cm2)	Initial Mass (grams)	Final Mass (grams)	Change Mass (grams)	Total Time (hours)	Stripping Rate (mil/hour)	Average S.R. (mil/hour)
Clepo 204	6-20-89	321	86	7.92	1.500	1.000	0.063	20.97	19.2415	19.2420	-0.0005	8.00	-1.48E-04	
Clepo 204	6-20-89	I-718	41	8.60	1.469	1.000	0.063	20.54	15.0016	15.0020	-0.0004	8.00	-1.11E-04	-1.92E-04
Clepo 204	6-20-89	I-718	42	8.60	1.500	1.000	0.063	20.97	15.1648	15.1658	-0.0010	8.00	-2.73E-04	
Clepo 204	6-20-89	HA 188	71	9.70	1.500	1.000	0.125	22.58	35.8755	35.8763	-0.0008	8.00	-1.80E-04	-1.24E-04
Clepo 204	6-20-89	HA 188	72	9.70	1.500	1.000	0.125	22.58	35.9065	35.9068	-0.0003	8.00	-6.74E-05	
Clepo 204	6-20-89	Cu	159	8.92	1.500	1.000	0.125	22.58	28.4416	28.4020	0.0396	8.00	9.68E-03	1.03E-02
Clepo 204	6-20-89	Cu	172	8.92	1.531	1.000	0.125	23.03	28.7032	28.6577	0.0455	8.00	1.09E-02	
Clepo 204	6-20-89	410	77	7.70	1.500	1.000	0.063	20.97	17.3573	17.3574	-0.0001	24.00	-1.02E-05	3.05E-05
Clepo 204	6-20-89	410	78	7.70	1.500	1.000	0.063	20.97	17.4268	17.4261	0.0007	24.00	7.11E-05	
Clepo 204	6-20-89	C4340	31	7.84	1.500	1.000	0.063	20.97	14.6140	14.6138	0.0002	24.00	2.00E-05	2.49E-05
Clepo 204	6-20-89	C4340	51	7.84	1.500	1.000	0.063	20.97	14.9722	14.9719	0.0003	24.00	2.99E-05	
Clepo 204	6-20-89	D6AC	20	8.20	1.531	1.000	0.125	23.03	27.7848	27.7838	0.0010	24.00	8.68E-05	9.22E-05
Clepo 204	6-20-89	D6AC	19	8.20	1.500	1.000	0.125	22.58	27.9234	27.9223	0.0011	24.00	9.75E-05	
Clepo 204	6-20-89	321	69	7.92	1.500	1.000	0.063	20.97	18.9567	18.9567	0.0000	24.00	0.00E+00	2.02E-05
Clepo 204	6-20-89	321	70	7.92	1.469	1.000	0.063	20.54	18.5796	18.5792	0.0004	24.00	4.03E-05	
Clepo 204	6-20-89	I-718	68	8.60	1.500	1.000	0.063	20.97	15.1426	15.1426	0.0000	24.00	0.00E+00	9.10E-06
Clepo 204	6-20-89	I-718	70	8.60	1.500	1.000	0.063	20.97	15.1136	15.1134	0.0002	24.00	1.82E-05	
Clepo 204	6-20-89	HA 188	19	9.70	1.500	1.000	0.125	22.58	35.6329	35.6326	0.0003	24.00	2.25E-05	1.50E-05
Clepo 204	6-20-89	HA 188	20	9.70	1.500	1.000	0.125	22.58	35.7235	35.7234	0.0001	24.00	7.49E-06	
Clepo 204	6-20-89	Cu	107	8.92	1.500	1.000	0.125	22.58	27.5901	27.4287	0.1614	24.00	1.31E-02	1.23E-02
Clepo 204	6-20-89	Cu	111	8.92	1.563	1.000	0.125	23.49	28.4359	28.2891	0.1468	24.00	1.15E-02	
Clepo 204	6-20-89	Ni-S	323	8.90	1.531	1.000	0.063	21.40	26.4363	26.2263	0.2100	1.00	4.34E-01	4.21E-01
Clepo 204	6-20-89	Ni-S	473	8.90	1.500	1.000	0.063	20.97	22.6055	22.4123	0.1932	1.00	4.08E-01	
Clepo 204	6-20-89	Ni-P	64	8.90	1.500	1.000	0.063	20.97	19.1014	19.0534	0.0480	1.00	1.01E-01	9.82E-02
Clepo 204	6-20-89	Ni-P	45	8.90	1.531	1.000	0.063	21.40	18.8192	18.7732	0.0460	1.00	9.51E-02	
Clepo 204	6-20-89	Ni-S	430	8.90	1.531	1.000	0.063	21.40	23.0080	22.7142	0.2938	2.00	3.04E-01	3.44E-01
Clepo 204	6-20-89	Ni-S	485	8.90	1.563	1.000	0.063	21.82	23.6849	23.3056	0.3793	2.00	3.84E-01	
Clepo 204	6-20-89	Ni-P	88	8.90	1.500	1.000	0.063	20.97	18.7602	18.6866	0.0736	2.00	7.76E-02	8.72E-02
Clepo 204	6-20-89	Ni-P	125	8.90	1.531	1.000	0.063	21.40	19.1115	19.0178	0.0937	2.00	9.69E-02	

Implementation Data

140 deg. F Mechanical Agitation

Clepo 204	8-23-90	410	52	7.70	2.0000	1.0220	0.0600	28.32	14.5991	15.5990	-0.9999	24.00	-7.52E-02
Clepo 204	8-23-90	316	12	8.00	2.0000	1.0190	0.0600	28.24	16.6068	16.6069	-0.0001	24.00	-7.26E-06
Clepo 204	8-23-90	C4340	89	7.84	2.0000	0.0990	0.0610	4.17	14.8180	14.8170	0.0010	24.00	5.02E-04
Clepo 204	8-23-90	D6AC	147	8.20	2.0000	1.0000	0.0670	27.97	16.2696	16.2691	0.0005	24.00	3.58E-05
Clepo 204	8-23-90	I-718	37	8.60	2.0000	1.0190	0.0620	28.30	16.1741	16.1746	-0.0005	24.00	-3.37E-05
Clepo 204	8-23-90	HA 188	50	9.70	2.0000	1.0050	0.0590	27.84	16.9440	16.9442	-0.0002	24.00	-1.21E-05
Clepo 204	8-23-90	17-4PH	66	7.80	2.0000	0.9990	0.0640	27.84	15.1835	15.1837	-0.0002	24.00	-1.51E-05
Clepo 204	8-23-90	S-NI	36	8.90	2.0360	1.0360	0.0790	29.82	20.3644	16.5856	3.7788	2.00	2.80E+00
Clepo 204	8-23-90	S-NI	38	8.90	2.0250	1.0520	0.0820	30.19	20.9917	15.1869	5.8048	4.00	2.13E+00
Clepo 204	8-23-90	P-Ni	120	8.90	2.0380	1.0130	0.0770	29.17	18.9384	18.0361	0.9023	4.00	3.42E-01
Clepo 204	8-23-90	P-Ni	152	8.90	2.0170	1.0110	0.0770	28.82	18.8682	16.8788	1.9894	8.00	3.82E-01

Stripper	Test Date	Coupon Material	Coupon #	Density (g/cm3)	Unmasked Dimensions in inches length	width	thick	Surface Area (cm2)	Initial Mass (grams)	Final Mass (grams)	Change Mass (grams)	Total Time (hours)	Stripping Rate (mil/hour)	Average S.R. (mil/hour)
134 deg. F	Mechanical Agitation													
Clepo 204	9-20-90	HA 188	108	9.70	1.4690	1.0000	0.0590	20.45	16.7854	16.7844	0.0010	24.00	8.27E-05	
Clepo 204	9-20-90	D6AC	130	8.20	1.5000	1.0150	0.0760	21.61	18.8301	18.8292	0.0009	24.00	8.33E-05	
Clepo 204	9-20-90	C4340	31	7.84	1.5000	0.0980	0.0610	3.12	14.6562	14.6550	0.0012	24.00	8.06E-04	
Clepo 204	9-20-90	316	17	8.00	1.5000	1.0020	0.0570	20.87	13.9053	13.9047	0.0006	24.00	5.90E-05	
Clepo 204	9-20-90	410	90	7.70	1.5000	1.0280	0.0590	21.43	14.1893	14.1884	0.0009	24.00	8.95E-05	
Clepo 204	9-20-90	I-718	30	8.60	1.5000	1.0000	0.0630	20.98	15.9999	15.9989	0.0010	24.00	9.09E-05	
Clepo 204	9-20-90	17-4PH	38	7.80	1.5000	1.0070	0.6300	35.78	14.8118	14.8114	0.0004	24.00	2.35E-05	
Clepo 204	9-20-90	S-Ni	139	8.90	1.5000	1.0140	0.0720	21.49	17.8890	17.5192	0.3698	3.00	2.54E-01	
Clepo 204	9-20-90	P-Ni	140	8.90	1.5000	1.0140	0.0730	21.52	18.0010	17.1770	0.8240	6.00	2.82E-01	
Clepo 204	9-20-90	Nitrited Steel	N/A	7.84	0.3710	0.8000	0.4300	8.11	20.7273	20.7269	0.0004	24.00	1.03E-04	
Clepo 204	10-18-90	Cr	17	7.20	1.0130	1.0170	0.0690	14.65	16.2005	16.2004	0.0001	25.00	1.49E-05	-7.32E-06
Clepo 204	10-18-90	Cr	125	7.20	0.9950	1.0180	0.0890	14.80	21.2368	21.2370	-0.0002	25.00	-2.96E-05	
130 deg. F	Mechanical Agitation Last basis metals protection test on implementation stripper/Clepo 204													
Clepo 204	11-5-90	316	26	8.00	2.0200	1.0000	0.0580	27.95	14.0960	14.0958	0.0002	24.00	1.47E-05	
Clepo 204	11-5-90	410	41	7.70	2.0190	1.0140	0.0610	28.40	14.6383	14.6383	0.0000	24.00	0.00E+00	
Clepo 204	11-5-90	17-4PH	50	7.80	1.9930	1.0070	0.0630	27.93	14.6784	14.6783	0.0001	24.00	7.53E-06	
Clepo 204	11-5-90	D6AC	92	8.20	2.0260	1.0070	0.0760	28.81	18.7112	18.7077	0.0035	24.00	2.43E-04	
Clepo 204	11-5-90	HA 188	33	9.70	2.0240	1.0040	0.0600	28.18	17.1980	17.1977	0.0003	24.00	1.80E-05	
Clepo 204	11-5-90	I-718	9	8.60	2.0008	1.0090	0.0630	28.09	16.0589	16.0586	0.0003	24.00	2.04E-05	
Clepo 204	11-5-90	C4340	91	7.84	2.0100	0.9980	0.0630	27.92	15.0096	15.0072	0.0024	24.00	1.80E-04	
127 deg. F	Magnetic Agitation Vol.-700 mL pH-10 KAFB Tk No. 110 Solution													
Clepo 204	11-7-90	S-Ni	347	8.90	2.0440	1.0390	0.0830	30.15	21.6142	20.1289	1.4853	3.00	7.26E-01	7.19E-01
Clepo 204	11-7-90	S-Ni	596	8.90	2.0460	1.0410	0.0830	30.23	22.2628	20.8033	1.4595	3.00	7.12E-01	
127 deg. F	Magnetic Agitation Vol-700 mL pH-10.7 KAFB Tk No. 110 Solution + NaOH													
Clepo 204	11-7-90	S-Ni	410	8.90	2.0530	1.0450	0.0870	30.57	23.3984	21.6401	1.7583	3.00	8.48E-01	8.59E-01
Clepo 204	11-7-90	S-Ni	518	8.90	2.0500	1.0500	0.0880	30.70	23.4670	21.6558	1.8112	3.00	8.70E-01	
127 deg. F	Magnetic Agitation Vol.-700 mL pH-9.84 KAFB Tk No. 110 Solution + Clepo 240T Regenerated													
Clepo 204	11-7-90	S-Ni	476	8.90	2.0430	1.5100	0.0880	42.98	23.3423	22.2446	1.0977	3.00	3.77E-01	4.45E-01
Clepo 204	11-7-90	S-Ni	546	8.90	2.0430	1.0470	0.0840	30.38	22.3046	21.2466	1.0580	3.00	5.13E-01	

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APPENDIX D

STRIPPING RATE DATA FOR THE FIELD TESTING AND IMPLEMENTATION OF ELECTROCHEMICALS' NICKELSOL

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Stripper	Test Date	Coupon Material	Coupon #	Density (g/cm3)	Unmasked Dimensions in inches length	width	thick	Surface Area (cm2)	Initial Mass (grams)	Final Mass (grams)	Change Mass (grams)	Total Time (hours)	Stripping Rate (mil/hour)	Average S.R (mil/hour)
Ambient – 80–90 deg. F pH – below range Small Tank Fresh Solution														
Ni Sol	8–14–89	410	39	7.70	1.438	1.000	0.063	20.11	17.6964	17.6956	0.0008	24.00	8.47E–05	8.47E–05
Ni Sol	8–14–89	410	40	7.70	1.438	1.000	0.063	20.11	17.8829	17.8821	0.0008	24.00	8.47E–05	
Ni Sol	8–14–89	321	52	7.92	1.469	1.000	0.063	20.54	15.1885	15.1878	0.0007	24.00	7.06E–05	7.13E–05
Ni Sol	8–14–89	321	39	7.92	1.438	1.000	0.063	20.11	14.9832	14.9825	0.0007	24.00	7.21E–05	
Ni Sol	8–14–89	I–718	115	8.60	1.438	1.000	0.063	20.11	16.2407	16.2404	0.0003	24.00	2.85E–05	5.57E–05
Ni Sol	8–14–89	I–718	112	8.60	1.313	1.000	0.063	18.40	15.9307	15.9299	0.0008	24.00	8.29E–05	
Ni Sol	8–14–89	HA 188	95	9.70	1.438	1.000	0.063	20.11	17.6403	17.6398	0.0005	24.00	4.20E–05	4.20E–05
Ni Sol	8–14–89	HA 188	98	9.70	1.438	1.000	0.063	20.11	17.5983	17.5978	0.0005	24.00	4.20E–05	
Ni Sol	8–14–89	Ni–S	448	8.90	1.438	1.000	0.063	20.11	26.0289	20.0747	5.9542	1.00	1.31E+01	1.86E+01
Ni Sol	8–14–89	Ni–S	332	8.90	1.406	1.000	0.063	19.68	21.8327	11.0665	10.7662	1.00	2.42E+01	
Ni Sol	8–14–89	Ni–P	55	8.90	1.406	1.000	0.063	19.68	18.5714	14.9375	3.6339	1.00	8.17E+00	5.84E+00
Ni Sol	8–14–89	Ni–P	70	8.90	1.469	1.000	0.063	20.54	18.9380	17.3075	1.6305	1.00	3.51E+00	
Ni Sol	8–14–89	Cu	87	8.92	1.469	1.000	0.125	22.13	27.2483	23.7848	3.4635	1.00	6.91E+00	5.86E+00
Ni Sol	8–14–89	Cu	93	8.92	1.375	1.000	0.125	20.77	27.9122	25.6442	2.2680	1.00	4.82E+00	
100 deg. F ph–below range Small Tank Agitation Fresh Solution														
Ni–Sol	8–16–89	410	99	7.70	1.469	1.000	0.063	20.54	18.3596	18.3558	0.0038	24.00	3.94E–04	3.89E–04
Ni–Sol	8–16–89	410	172	7.70	1.469	1.000	0.063	20.54	17.7699	17.7662	0.0037	24.00	3.84E–04	
Ni–Sol	8–16–89	321	53	7.92	1.469	1.000	0.063	20.54	15.1875	15.1869	0.0006	24.00	6.05E–05	3.03E–05
Ni–Sol	8–16–89	321	54	7.92	1.438	1.000	0.063	20.11	15.3218	15.3218	0.0000	24.00	0.00E+00	
Ni–Sol	8–16–89	I–718	113	8.60	1.500	1.000	0.063	20.97	16.0457	16.0456	0.0001	24.00	9.10E–06	3.24E–05
Ni–Sol	8–16–89	I–718	114	8.60	1.469	1.000	0.063	20.54	15.9514	15.9508	0.0006	24.00	5.57E–05	
Ni–Sol	8–16–89	HA 188	96	9.70	1.469	1.000	0.063	20.55	17.0188	17.0190	–0.0002	24.00	–1.65E–05	–4.11E–06
Ni–Sol	8–16–89	HA 188	97	9.70	1.469	1.000	0.063	20.55	17.4306	17.4305	0.0001	24.00	8.23E–06	
Ni–Sol	8–16–89	Ni–S	585	8.90	1.500	1.000	0.063	20.97	30.1016	***	***	1.00	>2.00E+01	>2.00E+01
Ni–Sol	8–16–89	Ni–S	544	8.90	1.406	1.000	0.063	19.68	23.2384	***	***	1.00	>2.00E+01	
Ni–Sol	8–16–89	Ni–P	169	8.90	1.438	1.000	0.063	20.11	18.5550	***	***	1.00	>8.00E+00	>8.00E+00
Ni–Sol	8–16–89	Ni–P	135	8.90	1.469	1.000	0.063	20.54	18.7915	***	***	1.00	>8.00E+00	
Ni–Sol	8–16–89	Cu	40	8.92	1.375	1.000	0.125	20.77	29.2848	22.1318	7.1530	1.00	1.52E+01	1.49E+01
Ni–Sol	8–16–89	Cu	75	8.92	1.438	1.000	0.125	21.67	28.9878	21.8336	7.1542	1.00	1.46E+01	
*** Unwaxed portion of coupon completely dissolved														
130 deg. F pH–below range Small Tank Agitation Fresh Solution														
Ni Sol	8–18–89	410	110	7.70	1.375	1.000	0.063	19.25	17.7866	8.3138	9.4728	24.00	1.05E+00	9.89E–01
Ni Sol	8–18–89	410	171	7.70	1.500	1.000	0.063	20.97	17.5784	8.4232	9.1552	24.00	9.30E–01	
Ni Sol	8–18–89	321	50	7.92	1.469	1.000	0.063	20.54	14.8619	14.8603	0.0016	24.00	1.61E–04	1.37E–05
Ni Sol	8–18–89	321	49	7.92	1.438	1.000	0.063	20.11	15.0775	15.0788	–0.0013	24.00	–1.34E–04	
Ni Sol	8–18–89	I–718	101	8.60	1.469	1.000	0.063	20.54	15.8350	15.8435	–0.0085	24.00	–7.89E–04	–4.41E–04
Ni Sol	8–18–89	I–718	100	8.60	1.469	1.000	0.063	20.54	16.0274	16.0284	–0.0010	24.00	–9.29E–05	
Ni Sol	8–18–89	HA 188	100	9.70	1.438	1.000	0.063	20.12	17.2233	17.2252	–0.0019	24.00	–1.60E–04	–1.18E–04
Ni Sol	8–18–89	HA 188	99	9.70	1.438	1.000	0.063	20.12	17.1025	17.1034	–0.0009	24.00	–7.56E–05	
Ni Sol	8–18–89	Ni–S	450	8.90	1.563	1.000	0.063	21.82	23.7326	23.7208	0.0118	0.25	9.57E–02	5.42E–02
Ni Sol	8–18–89	Ni–S	483	8.90	1.500	1.000	0.063	20.97	22.7112	22.7097	0.0015	0.25	1.27E–02	
Ni Sol	8–18–89	Ni–P	53	8.90	1.469	1.000	0.063	20.54	18.8388	18.8065	0.0323	0.25	2.78E–01	1.24E–01

Stripper	Test Date	Coupon Material	Coupon #	Density (g/cm3)	Unmasked Dimensions in inches length	width	thick	Surface Area (cm2)	Initial Mass (grams)	Final Mass (grams)	Change Mass (grams)	Total Time (hours)	Stripping Rate (mil/hour)	Average S.R. (mil/hour)
Ni Sol	8-18-89	Ni-P	282	8.90	1.531	1.000	0.063	21.40	18.5903	18.5939	-0.0036	0.25	-2.98E-02	
Ni Sol	8-18-89	Cu	11	8.92	1.500	1.000	0.125	22.58	29.0473	29.0463	0.0010	0.25	7.82E-03	5.93E-02
Ni Sol	8-18-89	Cu	81	8.92	1.438	1.000	0.125	21.67	29.2894	29.2758	0.0136	0.25	1.11E-01	

All plate metals were copper, when taken from solution. Solution out of balance.

130 deg. F pH-below range Fresh Solution Agitation Small Tank

Stripper	Test Date	Coupon Material	Coupon #	Density (g/cm3)	length	width	thick	Surface Area (cm2)	Initial Mass (grams)	Final Mass (grams)	Change Mass (grams)	Total Time (hours)	Stripping Rate (mil/hour)	Average S.R. (mil/hour)
Ni Sol	8-22-89	Ni-S	452	8.90	1.469	1.000	0.063	20.54	23.1675	23.1553	0.0122	0.50	5.26E-02	2.99E-02
Ni Sol	8-22-89	Ni-S	469	8.90	1.500	1.000	0.063	20.97	27.1029	27.1012	0.0017	0.50	7.17E-03	
Ni Sol	8-22-89	Ni-P	11	8.90	1.469	1.000	0.063	20.54	19.0078	18.9996	0.0082	0.50	3.53E-02	9.13E-02
Ni Sol	8-22-89	Ni-P	5	8.90	1.438	1.000	0.063	20.11	19.1370	19.1035	0.0335	0.50	1.47E-01	
Ni Sol	8-22-89	Cu	71	8.92	1.438	1.000	0.125	21.67	28.0124	28.0190	-0.0066	0.50	-2.69E-02	-2.78E-02
Ni Sol	8-22-89	Cu	95	8.92	1.469	1.000	0.125	22.13	29.4278	29.4350	-0.0072	0.50	-2.87E-02	

All plate metals were copper, when taken from solution. Maintained improperly.
Reran on 8-22-89 after adding 800 mL Electro-Brite NSX

130 deg. F pH-below range Small Tank Agitation Fresh Solution

Stripper	Test Date	Coupon Material	Coupon #	Density (g/cm3)	length	width	thick	Surface Area (cm2)	Initial Mass (grams)	Final Mass (grams)	Change Mass (grams)	Total Time (hours)	Stripping Rate (mil/hour)	Average S.R. (mil/hour)
Ni Sol	8-28-89	410	38	7.70	2.000	1.000	0.063	27.82	17.9214	***	***	24.00	***	
Ni Sol	8-28-89	410	37	7.70	2.000	1.000	0.063	27.82	17.7145	***	***	24.00	***	
Ni Sol	8-28-89	321	37	7.92	2.000	1.000	0.063	27.82	14.9594	14.9486	0.0108	24.00	8.04E-04	8.30E-04
Ni Sol	8-28-89	321	43	7.92	2.000	1.000	0.063	27.82	14.6708	14.6593	0.0115	24.00	8.56E-04	
Ni Sol	8-28-89	I-718	123	8.60	2.000	1.000	0.063	27.82	16.3897	16.3863	0.0034	24.00	2.33E-04	2.71E-04
Ni Sol	8-28-89	I-718	121	8.60	2.000	1.000	0.063	27.82	16.1892	16.1847	0.0045	24.00	3.09E-04	
Ni Sol	8-28-89	HA 188	89	9.70	2.000	1.000	0.063	27.84	16.9978	16.9941	0.0037	24.00	2.25E-04	2.40E-04
Ni Sol	8-28-89	HA 188	88	9.70	2.000	1.000	0.063	27.84	16.9846	16.9804	0.0042	24.00	2.55E-04	
Ni Sol	8-28-89	Ni-S	481	8.90	1.406	1.000	0.063	19.68	22.2963	11.7976	10.4987	0.25	9.44E+01	8.58E+01
Ni Sol	8-28-89	Ni-S	338	8.90	1.469	1.000	0.063	20.54	23.2745	14.3058	8.9687	0.25	7.73E+01	
Ni Sol	8-28-89	Ni-P	224	8.90	1.438	1.000	0.063	20.11	18.6595	15.0665	3.5930	0.25	3.16E+01	3.60E+01
Ni Sol	8-28-89	Ni-P	71	8.90	1.500	1.000	0.063	20.97	18.8663	14.0885	4.7778	0.25	4.03E+01	
Ni Sol	8-28-89	Cu	85	8.92	1.406	1.000	0.125	21.22	28.4733	25.0230	3.4503	0.25	2.87E+01	2.91E+01
Ni Sol	8-28-89	Cu	2	8.92	1.344	1.000	0.125	20.31	28.7398	25.3453	3.3945	0.25	2.95E+01	

Before running the above tests, we added 2.4 gal Ni-Sol & .4 gal Electro-Brite NSX. (According to results of titration.)
The solution got under the wax and dissolved the rods. I had to fish the base metals from the solution. I never did find the 410 coupons. (Probably dissolved them.)

90 deg. F pH-below range Agitation Small Tank 10 oz. $NiSO_4 \cdot 6H_2O$ per gal. (63.65 g Ni/gal)

Stripper	Test Date	Coupon Material	Coupon #	Density (g/cm3)	length	width	thick	Surface Area (cm2)	Initial Mass (grams)	Final Mass (grams)	Change Mass (grams)	Total Time (hours)	Stripping Rate (mil/hour)	Average S.R. (mil/hour)
Ni Sol	10-18-89	410	83	7.70	2.000	1.000	0.063	27.82	17.7633	17.7629	0.0004	24.00	3.06E-05	4.21E-05
Ni Sol	10-18-89	410	82	7.70	2.000	1.000	0.063	27.82	17.8645	17.8638	0.0007	24.00	5.36E-05	
Ni Sol	10-18-89	321	51	7.92	2.000	1.000	0.063	27.82	15.0516	15.0514	0.0002	24.00	1.49E-05	2.23E-05
Ni Sol	10-18-89	321	48	7.92	2.000	1.000	0.063	27.82	15.0734	15.0730	0.0004	24.00	2.98E-05	
Ni Sol	10-18-89	I-718	105	8.60	2.000	1.000	0.063	27.82	16.3965	16.3959	0.0006	24.00	4.11E-05	3.43E-05
Ni Sol	10-18-89	I-718	102	8.60	2.000	1.000	0.063	27.82	16.0959	16.0955	0.0004	24.00	2.74E-05	

Stripper	Test Date	Coupon Material	Coupon #	Density (g/cm3)	Unmasked Dimensions in inches length	width	thick	Surface Area (cm2)	Initial Mass (grams)	Final Mass (grams)	Change Mass (grams)	Total Time (hours)	Stripping Rate (mil/hour)	Average S.R. (mil/hour)
Ni Sol	10-18-89	HA 188	3	9.70	2.000	1.000	0.063	27.84	16.7391	16.7385	0.0006	24.00	3.64E-05	3.04E-05
Ni Sol	10-18-89	HA 188	2	9.70	2.000	1.000	0.063	27.84	16.8273	16.8269	0.0004	24.00	2.43E-05	
Ni Sol	10-18-89	316L	16	8.00	2.000	1.000	0.063	27.82	14.3650	14.3652	-0.0002	24.00	-1.47E-05	2.21E-05
Ni Sol	10-18-89	316L	17	8.00	2.000	1.000	0.063	27.82	14.3880	14.3872	0.0008	24.00	5.90E-05	
Ni Sol	10-18-89	Ni-S	443	8.90	1.438	1.000	0.063	20.11	25.4522	21.4609	3.9913	0.50	1.76E+01	1.60E+01
Ni Sol	10-18-89	Ni-S	519	8.90	1.438	1.000	0.063	20.11	23.1153	19.8195	3.2958	0.50	1.45E+01	
Ni Sol	10-18-89	Ni-P	273	8.90	1.438	1.000	0.063	20.11	18.7704	17.8209	0.9495	0.50	4.18E+00	4.15E+00
Ni Sol	10-18-89	Ni-P	230	8.90	1.406	1.000	0.063	19.68	18.8492	17.9325	0.9167	0.50	4.12E+00	
90 deg. F	pH-below range	[1/2 hr test]	Agitation-Mechanical + air	Solution Loaded with 63.65 g/gal Nickel										
Ni Sol	11-8-89	410	21	7.70	1.500	1.000	0.063	20.97	17.6534	17.6518	0.0016	24.00	1.63E-04	2.13E-04
Ni Sol	11-8-89	410	81	7.70	1.500	1.000	0.063	20.97	17.5872	17.5846	0.0026	24.00	2.64E-04	
Ni Sol	11-8-89	321	57	7.92	1.500	1.000	0.063	20.97	14.9399	14.9392	0.0007	24.00	6.91E-05	6.42E-05
Ni Sol	11-8-89	321	58	7.92	1.500	1.000	0.063	20.97	14.6595	14.6589	0.0006	24.00	5.93E-05	
Ni Sol	11-8-89	I-718	103	8.60	1.500	1.000	0.063	20.97	16.1145	16.1144	0.0001	24.00	9.10E-06	4.09E-05
Ni Sol	11-8-89	I-718	104	8.60	1.500	1.000	0.063	20.97	15.7182	15.7174	0.0008	24.00	7.28E-05	
Ni Sol	11-8-89	HA 188	1	9.70	1.500	1.000	0.063	20.98	17.0982	17.0978	0.0004	24.00	3.22E-05	-2.90E-04
Ni Sol	11-8-89	HA 188	4	9.70	1.500	1.000	0.063	20.98	16.9118	16.9194	-0.0076	24.00	-6.13E-04	
Ni Sol	11-8-89	316L	13	8.00	1.500	1.000	0.063	20.97	14.2469	14.2464	0.0005	24.00	4.89E-05	4.89E-05
Ni Sol	11-8-89	316L	14	8.00	1.500	1.000	0.063	20.97	14.4351	14.4346	0.0005	24.00	4.89E-05	
Ni Sol	11-8-89	Ni-S	545	8.90	1.500	1.000	0.063	20.97	22.2938	---	lost			1.97E+01
Ni Sol	11-8-89	Ni-S	578	8.90	1.500	1.000	0.063	20.97	22.1443	12.7876	9.3567	1.00	1.97E+01	
Ni Sol	11-8-89	Ni-P	185	8.90	1.500	1.000	0.063	20.97	18.2771	16.6015	1.6756	1.00	3.54E+00	3.46E+00
Ni Sol	11-8-89	Ni-P	254	8.90	1.500	1.000	0.063	20.97	18.5767	16.9726	1.6041	1.00	3.38E+00	
Ni Sol	11-17-89	Ni-S	568	8.90	1.500	1.000	0.063	20.97	22.3551	17.6551	4.7000	0.50	1.98E+01	2.42E+01
Ni Sol	11-17-89	Ni-S	509	8.90	1.500	1.000	0.063	20.97	21.9484	15.1756	6.7728	0.50	2.86E+01	
Ni Sol	11-17-89	Ni-P	160	8.90	1.500	1.000	0.063	20.97	18.7682	17.6523	1.1159	0.50	4.71E+00	4.87E+00
Ni Sol	11-17-89	Ni-P	122	8.90	1.500	1.000	0.063	20.97	19.1701	17.9766	1.1935	0.50	5.04E+00	
90 deg. F	pH-below range	[1/2 hr test]	Agitation-Mechanical + air											
Ni Sol	12-22-89	Ni-S	537	8.90	2.000	1.000	0.063	27.82	27.5385	20.8331	6.7054	0.50	2.13E+01	2.06E+01
Ni Sol	12-22-89	Ni-S	486	8.90	2.000	1.000	0.063	27.82	27.6396	21.3930	6.2466	0.50	1.99E+01	
Ni Sol	12-22-89	Ni-P	143	8.90	2.000	1.000	0.063	27.82	18.9569	17.4440	1.5129	0.50	4.81E+00	4.65E+00
Ni Sol	12-22-89	Ni-P	296	8.90	2.000	1.000	0.063	27.82	18.7077	17.2933	1.4144	0.50	4.50E+00	
90 deg. F	Mechanical Agitation	pH-<0	Ran without air											
Ni Sol	1-4-90	Ni-S	538	8.90	2.000	1.000	0.063	27.82	22.1104	16.0491	6.0613	0.50	1.93E+01	2.10E+01
Ni Sol	1-4-90	Ni-S	359	8.90	2.000	1.000	0.063	27.82	22.2499	15.1048	7.1451	0.50	2.27E+01	
Ni Sol	1-4-90	Ni-P	249	8.90	2.000	1.000	0.063	27.82	18.7660	17.3800	1.3860	0.50	4.41E+00	4.30E+00
Ni Sol	1-4-90	Ni-P	179	8.90	2.000	1.000	0.063	27.82	18.5863	17.2706	1.3157	0.50	4.18E+00	
90 deg. F	Mechanical Agitation	pH-<0	Ran with air											
Ni Sol	1-4-90	Ni-S	302	8.90	2.000	1.000	0.063	27.82	27.1034	20.7706	6.3328	0.50	2.01E+01	2.08E+01
Ni Sol	1-4-90	Ni-S	562	8.90	2.000	1.000	0.063	27.82	27.1295	20.3654	6.7641	0.50	2.15E+01	

Stripper	Test Date	Coupon Material	Coupon #	Density (g/cm3)	Unmasked Dimensions in inches length	width	thick	Surface Area (cm2)	Initial Mass (grams)	Final Mass (grams)	Change Mass (grams)	Total Time (hours)	Stripping Rate (mil/hour)	Average S.R. (mil/hour)
Ni Sol	1-4-90	Ni-P	44	8.90	2.000	1.000	0.063	27.82	19.2516	17.8627	1.3889	0.50	4.42E+00	4.52E+00
Ni Sol	1-4-90	Ni-P	215	8.90	2.000	1.000	0.063	27.82	18.8961	17.4415	1.4546	0.50	4.63E+00	
Ambient temp. Magnetic Stirring Vol.-800 mL														
Ni Sol	6-22-90	Ag	1	10.50	1.994	1.004	0.064	27.89	15.1833	15.1832	0.0001	24.00	5.60E-06	
Ambient temp. Magnetic Stirring														
Ni Sol	6-22-90	Ag	1	10.50	2.000	0.996	0.123	29.67	38.0123	37.9827	0.0296	2.00	1.87E-02	2.70E-02
Ni Sol	6-22-90	Ag	2	10.50	1.998	1.000	0.123	29.75	39.1030	38.9909	0.1121	4.00	3.53E-02	
Temp 83F Magnetic Stirring														
Ni Sol	6-27-90	Ams-Ti-4911	1	4.43	1.994	1.019	0.026	27.06	3.7710	3.7558	0.0152	24.00	2.08E-03	1.56E-03
Ni Sol	6-27-90	Ams-Ti-4911	2	4.43	1.953	1.020	0.026	26.53	3.6897	3.6749	0.0148	48.00	1.03E-03	
Ni Sol	6-27-90	Ams-Ti-4911	1	4.43	1.994	1.019	0.026	27.06	3.7558	3.7442	0.0116	24.00	1.59E-03	1.29E-03
Ni Sol	6-27-90	Ams-Ti-4911	2	4.43	1.953	1.020	0.026	26.53	3.6749	3.6607	0.0142	48.00	9.91E-04	
Ni Sol	6-27-90	Ams-Ti-4911	1	4.43	0.877" X 0.110" disk			9.75	4.5569	4.5506	0.0063	24.00	2.39E-03	1.78E-03
Ni Sol	6-27-90	Ams-Ti-4911	2	4.43	0.877" X 0.120" disk			9.93	5.0948	5.0885	0.0063	48.00	1.17E-03	
Ni Sol	6-27-90	Ams-Ti-4911	1	4.43	0.877" X 0.110" disk			9.75	4.5506	4.5458	0.0048	24.00	1.82E-03	1.38E-03
Ni Sol	6-27-90	Ams-Ti-4911	2	4.43	0.877" X 0.120" disk			9.93	5.0885	5.0835	0.0050	48.00	9.32E-04	
Ambient temp. (23.5 deg. C) Vol.-800 mL Magnetic Stirring pH-.004														
Ni Sol	7-15-90	Ams-Ti-4911	3	4.43	1.946	1.014	0.026	26.28	3.6622	3.6615	0.0007	24.00	9.86E-05	4.93E-05
Ni Sol	7-15-90	Ams-Ti-4911	R3	4.43	0.876" X 0.113" disk			9.78	4.8285	4.8285	0.0000	24.00	0.00E+00	
Ni Sol	7-15-90	316	16	8.00	2.013	1.000	0.058	27.85	14.0210	14.0211	-0.0001	24.00	-7.36E-06	
Ni Sol	7-15-90	410	102	7.70	2.016	1.023	0.060	28.57	14.7850	14.7847	0.0003	24.00	2.24E-05	
Ni Sol	7-15-90	321	132	7.92	2.015	1.024	0.062	28.65	15.5712	15.5709	0.0003	24.00	2.17E-05	
Ni Sol	7-15-90	I-718	54	8.60	2.003	1.014	0.620	46.29	16.3084	16.3078	0.0006	24.00	2.47E-05	
Ni Sol	7-15-90	HA 188	87	9.70	2.001	0.994	0.126	29.73	35.5292	35.5284	0.0008	24.00	4.55E-05	
Ni Sol	7-15-90	17-4PH	14	7.80	1.994	1.004	0.064	27.89	15.1833	15.1832	0.0001	24.00	7.54E-06	
Ambient temp. Air Spray Agitation														
Ni Sol	7-16-90	316	15	8.00	2.020	1.009	0.058	28.19	14.1183	14.1184	-0.0001	24.00	-7.27E-06	
Ni Sol	7-16-90	410	101	7.70	2.018	1.010	0.060	28.25	14.7238	14.7234	0.0004	24.00	3.02E-05	
Ni Sol	7-16-90	I-718	50	8.60	2.005	1.000	0.063	27.91	16.1081	16.1078	0.0003	24.00	2.05E-05	
Ni Sol	7-16-90	HA 188	110	9.70	2.018	1.000	0.060	27.99	16.9352	16.9347	0.0005	24.00	3.02E-05	
Ni Sol	7-16-90	17-4PH	12	7.80	1.997	1.005	0.062	27.90	14.8358	14.8354	0.0004	24.00	3.02E-05	
Ni Sol	7-16-90	Ni-P	143	8.90	2.020	1.010	0.071	28.64	18.0371	17.0860	0.9511	2.00	7.35E-01	7.59E-01
Ni Sol	7-16-90	Ni-P	144	8.90	2.016	1.001	0.071	28.35	17.8600	15.8538	2.0062	4.00	7.82E-01	
Ambient temp. Air Spray Agitation														
Ni Sol	7-23-90	Ams-Ti-4911	3	4.43	1.945	1.014	0.026	26.27	3.6615	3.6616	-0.0001	39.25	-8.62E-06	-3.90E-05
Ni Sol	7-23-90	Ams-Ti-4911	R3	4.43	0.876" X 0.113" disk			9.78	4.8285	4.8288	-0.0003	39.25	-6.95E-05	
Ni Sol	7-23-90	316	16	8.00	2.012	1.000	0.058	27.84	14.0211	14.0209	0.0002	39.25	9.01E-06	

Stripper	Test Date	Coupon Material	Coupon #	Density (g/cm3)	Unmasked Dimensions in inches: length	width	thick	Surface Area (cm2)	Initial Mass (grams)	Final Mass (grams)	Change Mass (grams)	Total Time (hours)	Stripping Rate (mil/hour)	Average S.R. (mil/hour)
Ni Sol	7-23-90	410	102	7.70	2.016	1.023	0.060	28.57	14.7847	14.7841	0.0006	39.25	2.74E-05	
Ni Sol	7-23-90	321	132	7.92	2.015	1.024	0.062	28.65	15.5709	15.5708	0.0001	39.25	4.42E-06	
Ni Sol	7-23-90	I-718	54	8.60	2.003	1.014	0.063	28.25	16.3078	16.3074	0.0004	39.25	1.65E-05	
Ni Sol	7-23-90	HA 188	87	9.70	2.000	0.994	0.123	29.61	35.5284	35.5284	0.0000	39.25	0.00E+00	
Ni Sol	7-23-90	17-4PH	14	7.80	1.994	1.004	0.064	27.89	15.1832	15.1832	0.0000	39.25	0.00E+00	
Ambient temp. (27 deg. C) Air Spray Agitation														
Ni Sol	7-24-90	Ni-P	143	8.90	2.020	1.008	0.068	28.49	17.0860	16.0470	1.0390	2.00	8.07E-01	6.50E-01
Ni Sol	7-24-90	Ni-P	144	8.90	2.012	1.011	0.064	28.33	15.8538	15.2210	0.6328	2.00	4.94E-01	
Ambient temp. (27 deg. C) Air Spray Agitation														
Ni Sol	7-27-90	Ni-P	137	8.90	2.024	1.027	0.072	29.18	18.1507	16.7184	1.4323	2.00	1.09E+00	1.11E+00
Ni Sol	7-27-90	Ni-P	138	8.90	2.024	1.016	0.072	28.89	18.0107	17.2714	0.7393	1.00	1.13E+00	
Ambient temp. Air Spray Agitation														
Ni Sol	8-10-90	316	15	8.00	2.000	1.000	0.063	27.82	14.1184	14.1185	-0.0001	56.00	-3.16E-06	
Ni Sol	8-10-90	410	101	7.70	2.000	1.000	0.063	27.82	14.7233	14.7220	0.0013	56.00	4.27E-05	
Ni Sol	8-10-90	I-718	50	8.60	2.000	1.000	0.063	27.82	16.9347	16.1075	0.8272	56.00	2.43E-02	
Ni Sol	8-10-90	HA 188	110	9.70	2.000	1.000	0.063	27.82	14.9346	16.9347	-2.0001	56.00	-5.21E-02	
Ni Sol	8-10-90	17-4PH	12	7.80	2.000	1.000	0.063	27.82	14.8353	14.8352	0.0001	56.00	3.24E-06	
Ni Sol	8-10-90	Ni-P	137	8.90	2.000	1.000	0.066	27.94	16.7184	15.9984	0.7200	1.00	1.14E+00	1.22E+00
Ni Sol	8-10-90	Ni-P	138	8.90	2.000	1.000	0.069	28.03	17.2714	15.6185	1.6529	2.00	1.30E+00	
Ambient (25 deg. C) pH-.24 (acid)														
Ni Sol	9-27-90	316	77	8.00	1.438	1.003	0.058	20.06	14.1586	14.1588	-0.0002	24.00	-2.04E-05	
Ni Sol	9-27-90	410	39	7.70	1.469	1.002	0.060	20.52	14.7509	14.7262	0.0247	24.00	2.56E-03	
Ni Sol	9-27-90	I-718	36	8.60	1.469	1.006	0.062	20.65	16.1384	16.1383	0.0001	24.00	9.24E-06	
Ni Sol	9-27-90	HA 188	142	9.70	1.438	1.000	0.061	20.08	17.2988	17.2986	0.0002	24.00	1.68E-05	
Ni Sol	9-27-90	17-4PH	46	7.80	1.406	1.005	0.063	19.78	14.9009	14.9006	0.0003	24.00	3.19E-05	
Ni Sol	9-27-90	Ams-Ti-4911	N/A	4.43	1.438	1.005	0.026	19.30	3.6752	3.6698	0.0054	24.00	1.04E-03	
Ni Sol	9-28-90	Ni-P	24	8.90	2.015	1.022	0.069	28.82	17.0624	15.7318	1.3306	1.00	2.04E+00	3.41E+00
Ni Sol	9-28-90	Ni-P	50	8.90	2.029	1.021	0.071	29.06	17.5433	11.2571	6.2862	2.00	4.79E+00	
Ni Sol	9-28-90	Ni-P	141	8.90	2.024	1.012	0.073	28.81	18.0418	17.3203	0.7215	1.00	1.11E+00	1.11E+00
Ni Sol	9-28-90	Ni-P	142	8.90	2.025	1.010	0.072	28.74	18.0264	16.5915	1.4349	2.00	1.10E+00	
Ni Sol	9-28-90	Ni-S	343	8.90	2.040	1.035	0.080	29.88	21.9344	16.1631	5.7713	1.00	8.54E+00	8.32E+00
Ni Sol	9-28-90	Ni-S	440	8.90	2.045	1.035	0.080	29.96	21.9385	10.9599	10.9786	2.00	8.11E+00	
Ambient temp. (25 deg. C) Air Agitation														
Ni Sol	11-1-90	HA 188	143	9.70	2.012	1.002	0.060	27.96	17.1789	17.1788	0.0001	24.00	6.05E-06	
Ni Sol	11-1-90	316	27	8.00	2.013	1.007	0.059	28.07	13.6613	13.6610	0.0003	24.00	2.19E-05	
Ni Sol	11-1-90	410	40	7.70	2.018	1.010	0.059	28.22	14.1328	14.1321	0.0007	24.00	5.28E-05	

Stripper	Test Date	Coupon Material	Coupon #	Density (g/cm3)	Unmasked Dimensions in inches length	width	thick	Surface Area (cm2)	Initial Mass (grams)	Final Mass (grams)	Change Mass (grams)	Total Time (hours)	Stripping Rate (mil/hour)	Average S.R. (mil/hour)
Ni Sol	11-1-90	I-178	34	8.60	2.011	1.000	0.063	27.99	16.1349	16.1342	0.0007	24.00	4.77E-05	
Ni Sol	11-1-90	17-4PH	53	7.80	1.989	1.014	0.062	28.02	14.6744	14.6740	0.0004	24.00	3.00E-05	
Ni Sol	11-1-90	Ams-Ti-4911	N/A	4.43	1.979	1.019	0.026	26.86	3.6556	3.6479	0.0077	24.00	1.06E-03	
Ni Sol	11-1-90	Ni-P	210	8.90	2.023	1.013	0.074	28.86	18.6584	14.1422	4.5162	2.00	3.46E+00	
Ni Sol	11-1-90	Ni-P	42	8.90	2.005	1.018	0.070	28.61	17.1106	14.6626	2.4480	2.00	1.89E+00	
Ni Sol	11-1-90	Ni-P	136	8.90	2.023	1.015	0.072	28.85	18.0641	16.2698	1.7943	3.00	9.17E-01	

APPENDIX E

STRIPPING RATE DATA FOR THE FIELD TESTING OF METALX'S B-9 NICKEL STRIPPER

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Stripper	Test Date	Coupon Material	Coupon #	Density (g/cm3)	Unmasked Dimensions in inches length	width	thick	Surface Area (cm2)	Initial Mass (grams)	Final Mass (grams)	Change Mass (grams)	Total Time (hours)	Stripping Rate (mil/hour)	Average S.R. (mil/hr)
120 deg. F Small Tank pH-10.0 Mechanical Agitation														
B-9	2-26-90	410	96	7.70	2.000	1.000	0.063	27.84	14.3337	14.3340	-0.0003	24.00	-2.30E-05	-1.53E-05
B-9	2-26-90	410	99	7.70	2.000	1.000	0.063	27.84	14.6190	14.6191	-0.0001	24.00	-7.65E-06	
B-9	2-26-90	C4340	46	7.84	2.000	1.000	0.063	27.84	14.8150	14.8149	0.0001	24.00	7.52E-06	3.76E-06
B-9	2-26-90	C4340	47	7.84	2.000	1.000	0.063	27.84	14.7217	14.7217	0.0000	24.00	0.00E+00	
B-9	2-26-90	D6AC	43	8.20	2.000	1.000	0.125	29.84	20.1245	20.1241	0.0004	24.00	2.68E-05	3.02E-05
B-9	2-26-90	D6AC	44	8.20	2.000	1.000	0.125	29.84	17.4874	17.4869	0.0005	24.00	3.35E-05	
B-9	2-26-90	321	64	7.92	2.000	1.000	0.063	27.84	15.0557	15.0560	-0.0003	24.00	-2.23E-05	-2.23E-05
B-9	2-26-90	321	65	7.92	2.000	1.000	0.063	27.84	15.2922	15.2925	-0.0003	24.00	-2.23E-05	
B-9	2-26-90	I-718	82	8.60	2.000	1.000	0.063	27.84	15.9776	15.9782	-0.0006	24.00	-4.11E-05	-3.43E-05
B-9	2-26-90	I-718	83	8.60	2.000	1.000	0.063	27.84	15.9348	15.9352	-0.0004	24.00	-2.74E-05	
B-9	2-26-90	HA 188	05	9.70	2.000	1.000	0.063	27.84	16.4157	16.4162	-0.0005	24.00	-3.04E-05	-2.73E-05
B-9	2-26-90	HA 188	06	9.70	2.000	1.000	0.063	27.84	16.8115	16.8119	-0.0004	24.00	-2.43E-05	
B-9	2-26-90	316	021	8.00	2.000	1.000	0.063	27.84	14.4373	14.4374	-0.0001	24.00	-7.37E-06	-1.10E-05
B-9	2-26-90	316	022	8.00	2.000	1.000	0.063	27.84	14.2286	14.2288	-0.0002	24.00	-1.47E-05	
B-9	2-26-90	Ni-S	326	8.90	2.000	1.000	0.063	27.84	22.6558	22.1595	0.4963	1.00	7.89E-01	7.84E-01
B-9	2-26-90	Ni-S	336	8.90	2.000	1.000	0.063	27.84	23.4147	22.9248	0.4899	1.00	7.78E-01	
B-9	2-26-90	Ni-P	054	8.90	2.000	1.000	0.063	27.84	18.7884	18.4680	0.3204	1.00	5.09E-01	4.56E-01
B-9	2-26-90	Ni-P	133	8.90	2.000	1.000	0.063	27.84	18.8091	18.5554	0.2537	1.00	4.03E-01	
B-9	2-26-90	Ni-S	361	8.90	2.000	1.000	0.063	27.84	22.8192	21.9233	0.8959	2.00	7.12E-01	7.38E-01
B-9	2-26-90	Ni-S	411	8.90	2.000	1.000	0.063	27.84	26.2333	25.2722	0.9611	2.00	7.64E-01	
B-9	2-26-90	Ni-P	163	8.90	2.000	1.000	0.063	27.84	18.7608	18.2028	0.5580	2.00	4.43E-01	4.68E-01
B-9	2-26-90	Ni-P	171	8.90	2.000	1.000	0.063	27.84	18.9303	18.3092	0.6211	2.00	4.93E-01	
B-9	2-26-90	Ni-S	539	8.90	2.000	1.000	0.063	27.84	21.7570	20.1678	1.5892	4.00	6.31E-01	6.29E-01
B-9	2-26-90	Ni-S	559	8.90	2.000	1.000	0.063	27.84	23.4070	21.8287	1.5783	4.00	6.27E-01	
B-9	2-26-90	Ni-P	213	8.90	2.000	1.000	0.063	27.84	18.8498	17.5695	1.2803	4.00	5.09E-01	5.10E-01
B-9	2-26-90	Ni-P	287	8.90	2.000	1.000	0.063	27.84	19.0302	17.7435	1.2867	4.00	5.11E-01	
140 deg. F Small Tank pH-10.0 Mechanical Agitation 2nd Test														
B-9	2-28-90	410	96	7.70	2.000	1.000	0.063	27.84	14.3340	14.3333	0.0007	24.00	5.36E-05	3.83E-05
B-9	2-28-90	410	99	7.70	2.000	1.000	0.063	27.84	14.6191	14.6188	0.0003	24.00	2.30E-05	
B-9	2-28-90	C4340	46	7.84	2.000	1.000	0.063	27.84	14.8149	14.8142	0.0007	24.00	5.26E-05	4.89E-05
B-9	2-28-90	C4340	47	7.84	2.000	1.000	0.063	27.84	14.7217	14.7211	0.0006	24.00	4.51E-05	
B-9	2-28-90	D6AC	43	8.20	2.000	1.000	0.125	29.84	20.1241	20.1235	0.0006	24.00	4.02E-05	5.70E-05
B-9	2-28-90	D6AC	44	8.20	2.000	1.000	0.125	29.84	17.4869	17.4858	0.0011	24.00	7.37E-05	
B-9	2-28-90	321	64	7.92	2.000	1.000	0.063	27.84	15.0560	15.0554	0.0006	24.00	4.46E-05	3.35E-05
B-9	2-28-90	321	65	7.92	2.000	1.000	0.063	27.84	15.2925	15.2922	0.0003	24.00	2.23E-05	
B-9	2-28-90	I-718	82	8.60	2.000	1.000	0.063	27.84	15.9782	15.9779	0.0003	24.00	2.06E-05	3.77E-05
B-9	2-28-90	I-718	83	8.60	2.000	1.000	0.063	27.84	16.9352	16.9344	0.0008	24.00	5.48E-05	
B-9	2-28-90	HA 188	05	9.70	2.000	1.000	0.063	27.84	16.4162	16.4157	0.0005	24.00	3.04E-05	2.73E-05
B-9	2-28-90	HA 188	06	9.70	2.000	1.000	0.063	27.84	16.8119	16.8115	0.0004	24.00	2.43E-05	
B-9	2-28-90	316	021	8.00	2.000	1.000	0.063	27.84	14.4374	14.4367	0.0007	24.00	5.16E-05	4.79E-05
B-9	2-28-90	316	022	8.00	2.000	1.000	0.063	27.84	14.2288	14.2282	0.0006	24.00	4.42E-05	
B-9	2-28-90	Ni-S	333	8.90	2.000	1.000	0.063	27.84	22.2722	21.3904	0.8818	1.00	1.40E+00	1.41E+00
B-9	2-28-90	Ni-S	346	8.90	2.000	1.000	0.063	27.84	22.4274	21.5364	0.8910	1.00	1.42E+00	
B-9	2-28-90	Ni-P	220	8.90	2.000	1.000	0.063	27.84	18.8032	18.3748	0.4284	1.00	6.81E-01	7.51E-01
B-9	2-28-90	Ni-P	225	8.90	2.000	1.000	0.063	27.84	18.6513	18.1349	0.5164	1.00	8.21E-01	

Stripper	Test Date	Coupon Material	Coupon #	Density (g/cm3)	Unmasked Dimensions in inches length	width	thick	Surface Area (cm2)	Initial Mass (grams)	Final Mass (grams)	Change Mass (grams)	Total Time (hours)	Stripping Rate (mil/hour)	Average S.R. (mil/hr)
B-9	2-28-90	Ni-S	385	8.90	2.000	1.000	0.063	27.84	22.2392	20.7342	1.5050	2.00	1.20E+00	1.22E+00
B-9	2-28-90	Ni-S	388	8.90	2.000	1.000	0.063	27.84	21.9846	20.4188	1.5658	2.00	1.24E+00	
B-9	2-28-90	Ni-P	226	8.90	2.000	1.000	0.063	27.84	18.6925	17.5675	1.1250	2.00	8.94E-01	8.41E-01
B-9	2-28-90	Ni-P	240	8.90	2.000	1.000	0.063	27.84	18.6935	17.7018	0.9917	2.00	7.88E-01	
B-9	2-28-90	Ni-S	398	8.90	2.000	1.000	0.063	27.84	22.2982	19.8792	2.4190	4.00	9.61E-01	9.96E-01
B-9	2-28-90	Ni-S	415	8.90	2.000	1.000	0.063	27.84	23.2648	20.6701	2.5947	4.00	1.03E+00	
B-9	2-28-90	Ni-P	256	8.90	2.000	1.000	0.063	27.84	19.0022	16.9783	2.0239	4.00	8.04E-01	7.23E-01
B-9	2-28-90	Ni-P	280	8.90	2.000	1.000	0.063	27.84	18.7026	17.0884	1.6142	4.00	6.41E-01	
150 deg. F Small Tank pH-10.10 Mechanical Agitation 3rd Test														
B-9	3-02-90	410	96	7.70	2.000	1.000	0.063	27.84	14.3333	14.3334	-0.0001	24.00	-7.65E-06	-3.32E-20
B-9	3-02-90	410	99	7.70	2.000	1.000	0.063	27.84	14.6183	14.6182	0.0001	24.00	7.65E-06	
B-9	3-02-90	C4340	46	7.84	2.000	1.000	0.063	27.84	14.8142	14.8133	0.0009	24.00	6.76E-05	7.89E-05
B-9	3-02-90	C4340	47	7.84	2.000	1.000	0.063	27.84	14.7211	14.7199	0.0012	24.00	9.02E-05	
B-9	3-02-90	D6AC	43	8.20	2.000	1.000	0.125	29.84	20.1235	20.1226	0.0009	24.00	6.03E-05	4.36E-05
B-9	3-02-90	D6AC	44	8.20	2.000	1.000	0.125	29.84	17.4858	17.4854	0.0004	24.00	2.68E-05	
B-9	3-02-90	321	64	7.92	2.000	1.000	0.063	27.84	15.0554	15.0552	0.0002	24.00	1.49E-05	1.12E-05
B-9	3-02-90	321	65	7.92	2.000	1.000	0.063	27.84	15.2922	15.2921	0.0001	24.00	7.44E-06	
B-9	3-02-90	I-718	82	8.60	2.000	1.000	0.063	27.84	15.9779	15.9778	0.0001	24.00	6.85E-06	-2.97E-20
B-9	3-02-90	I-718	83	8.60	2.000	1.000	0.063	27.84	16.9344	16.9345	-0.0001	24.00	-6.85E-06	
B-9	3-02-90	HA 188	05	9.70	2.000	1.000	0.063	27.84	16.4157	16.4157	0.0000	24.00	0.00E+00	0.00E+00
B-9	3-02-90	HA 188	06	9.70	2.000	1.000	0.063	27.84	16.8115	16.8115	0.0000	24.00	0.00E+00	
B-9	3-02-90	316	021	8.00	2.000	1.000	0.063	27.84	14.4367	14.4371	-0.0004	24.00	-2.95E-05	-1.84E-05
B-9	3-02-90	316	022	8.00	2.000	1.000	0.063	27.84	14.2282	14.2283	-0.0001	24.00	-7.37E-06	
B-9	3-02-90	Ni-S	310	8.90	2.000	1.000	0.063	27.84	22.3195	21.0759	1.2436	1.00	1.98E+00	1.94E+00
B-9	3-02-90	Ni-S	316	8.90	2.000	1.000	0.063	27.84	21.5135	20.3156	1.1979	1.00	1.90E+00	
B-9	3-02-90	Ni-P	104	8.90	2.000	1.000	0.063	27.84	18.8459	18.1538	0.6921	1.00	1.10E+00	1.17E+00
B-9	3-02-90	Ni-P	116	8.90	2.000	1.000	0.063	27.84	18.9108	18.1271	0.7837	1.00	1.25E+00	
B-9	3-02-90	Ni-S	363	8.90	2.000	1.000	0.063	27.84	23.5250	21.6099	1.9151	2.00	1.52E+00	1.57E+00
B-9	3-02-90	Ni-S	371	8.90	2.000	1.000	0.063	27.84	24.6302	22.6005	2.0297	2.00	1.61E+00	
B-9	3-02-90	Ni-P	134	8.90	2.000	1.000	0.063	27.84	18.6875	17.5798	1.1077	2.00	8.80E-01	1.05E+00
B-9	3-02-90	Ni-P	156	8.90	2.000	1.000	0.063	27.84	18.8594	17.3314	1.5280	2.00	1.21E+00	
B-9	3-02-90	Ni-S	374	8.90	2.000	1.000	0.063	27.84	24.0466	20.7826	3.2640	4.00	1.30E+00	1.28E+00
B-9	3-02-90	Ni-S	594	8.90	2.000	1.000	0.063	27.84	23.5349	20.3629	3.1720	4.00	1.26E+00	
B-9	3-02-90	Ni-P	197	8.90	2.000	1.000	0.063	27.84	18.9663	16.6022	2.3641	4.00	9.39E-01	9.36E-01
B-9	3-02-90	Ni-P	212	8.90	2.000	1.000	0.063	27.84	18.7471	16.3982	2.3489	4.00	9.33E-01	
150 deg. F Loaded metal solution at 0.945 g Ni/gal pH-10.12 Mechanical Agitation														
B-9	3-09-90	Ni-S	432	8.90	2.000	1.000	0.063	27.84	22.2168	21.2447	0.9721	2.00	7.72E-01	7.51E-01
B-9	3-09-90	Ni-S	460	8.90	2.000	1.000	0.063	27.84	22.9664	22.0481	0.9183	2.00	7.30E-01	
B-9	3-09-90	Ni-P	055	8.90	2.000	1.000	0.063	27.84	18.8906	18.3431	0.5475	2.00	4.35E-01	4.39E-01
B-9	3-09-90	Ni-P	067	8.90	2.000	1.000	0.063	27.84	18.9836	18.4266	0.5570	2.00	4.43E-01	
B-9	3-09-90	Ni-S	490	8.90	2.000	1.000	0.063	27.84	22.7737	21.0529	1.7208	4.00	6.84E-01	6.67E-01
B-9	3-09-90	Ni-S	511	8.90	2.000	1.000	0.063	27.84	22.8824	21.2433	1.6391	4.00	6.51E-01	
B-9	3-09-90	Ni-P	087	8.90	2.000	1.000	0.063	27.84	18.7425	17.8954	0.8471	4.00	3.37E-01	3.95E-01
B-9	3-09-90	Ni-P	077	8.90	2.000	1.000	0.063	27.84	19.1455	18.0026	1.1429	4.00	4.54E-01	
B-9	3-09-90	Ni-S	397	8.90	2.000	1.000	0.063	27.84	21.8403	21.3549	0.4854	1.00	7.71E-01	7.41E-01

Stripper	Test Date	Coupon Material	Coupon #	Density (g/cm3)	Unmasked Dimensions in inches length	width	thick	Surface Area (cm2)	Initial Mass (grams)	Final Mass (grams)	Change Mass (grams)	Total Time (hours)	Stripping Rate (mil/hour)	Average S.R. (mil/hr)
B-9	3-09-90	Ni-S	416	8.90	2.000	1.000	0.063	27.84	22.5837	22.1361	0.4476	1.00	7.11E-01	
B-9	3-09-90	Ni-P	042	8.90	2.000	1.000	0.063	27.84	18.9863	18.6628	0.3235	1.00	5.14E-01	5.18E-01
B-9	3-09-90	Ni-P	047	8.90	2.000	1.000	0.063	27.84	18.9351	18.6065	0.3286	1.00	5.22E-01	
150 deg. F Mechanical Agitation Loaded metal solution at 1.58 oz Ni/gal pH-10.15														
B-9	3-16-90	Ni-S	304	8.90	2.000	1.000	0.063	27.84	22.9150	22.8041	0.1109	1.00	1.76E-01	1.83E-01
B-9	3-16-90	Ni-S	329	8.90	2.000	1.000	0.063	27.84	21.4992	21.3796	0.1196	1.00	1.90E-01	
B-9	3-16-90	Ni-P	049	8.90	2.000	1.000	0.063	27.84	19.0253	18.9439	0.0814	1.00	1.29E-01	1.27E-01
B-9	3-16-90	Ni-P	051	8.90	2.000	1.000	0.063	27.84	19.1323	19.0537	0.0786	1.00	1.25E-01	
B-9	3-16-90	Ni-S	370	8.90	2.000	1.000	0.063	27.84	23.0405	22.8351	0.2054	2.00	1.63E-01	1.70E-01
B-9	3-16-90	Ni-S	381	8.90	2.000	1.000	0.063	27.84	27.4254	27.2031	0.2223	2.00	1.77E-01	
B-9	3-16-90	Ni-P	059	8.90	2.000	1.000	0.063	27.84	18.7067	18.5638	0.1429	2.00	1.14E-01	1.13E-01
B-9	3-16-90	Ni-P	089	8.90	2.000	1.000	0.063	27.84	18.6806	18.5400	0.1406	2.00	1.12E-01	
B-9	3-16-90	Ni-S	395	8.90	2.000	1.000	0.063	27.84	22.1934	21.7203	0.4731	4.00	1.88E-01	1.89E-01
B-9	3-16-90	Ni-S	434	8.90	2.000	1.000	0.063	27.84	24.1831	23.7064	0.4767	4.00	1.89E-01	
B-9	3-16-90	Ni-P	147	8.90	2.000	1.000	0.063	27.84	18.5596	18.2957	0.2639	4.00	1.05E-01	1.19E-01
B-9	3-16-90	Ni-P	208	8.90	2.000	1.000	0.063	27.84	18.6372	18.3003	0.3369	4.00	1.34E-01	
150 deg. F Mechanical Agitation Basis Metals at 1.58 oz Ni/gal of solution pH-10.15														
B-9	3-28-90	410 SS	96	7.70	2.000	1.000	0.063	27.84	14.3344	14.3341	0.0003	24.00	2.30E-05	7.65E-06
B-9	3-28-90	410 SS	99	7.70	2.000	1.000	0.063	27.84	14.6195	14.6196	-0.0001	24.00	-7.65E-06	
B-9	3-28-90	C4340	46	7.84	2.000	1.000	0.063	27.84	14.8138	14.8140	-0.0002	24.00	-1.50E-05	4.13E-05
B-9	3-28-90	C4340	47	7.84	2.000	1.000	0.063	27.84	14.7199	14.7186	0.0013	24.00	9.77E-05	
B-9	3-28-90	D6AC	43	8.20	2.000	1.000	0.125	29.84	20.1228	20.1212	0.0016	24.00	1.07E-04	4.02E-05
B-9	3-28-90	D6AC	44	8.20	2.000	1.000	0.125	29.84	17.4854	17.4858	-0.0004	24.00	-2.68E-05	
B-9	3-28-90	321	64	7.92	2.000	1.000	0.063	27.84	15.0561	15.0559	0.0002	24.00	1.49E-05	1.49E-05
B-9	3-28-90	321	65	7.92	2.000	1.000	0.063	27.84	15.2928	15.2926	0.0002	24.00	1.49E-05	
B-9	3-28-90	I-718	82	8.60	2.000	1.000	0.063	27.84	15.9785	15.9782	0.0003	24.00	2.06E-05	2.74E-05
B-9	3-28-90	I-718	83	8.60	2.000	1.000	0.063	27.84	15.9352	15.9347	0.0005	24.00	3.43E-05	
B-9	3-28-90	HA 188	05	9.70	2.000	1.000	0.063	27.84	16.4163	16.4163	0.0000	24.00	0.00E+00	-3.04E-06
B-9	3-28-90	HA 188	06	9.70	2.000	1.000	0.063	27.84	16.8120	16.8121	-0.0001	24.00	-6.07E-06	
B-9	3-28-90	316	21	8.00	2.000	1.000	0.063	27.84	14.4376	14.4378	-0.0002	24.00	-1.47E-05	-1.10E-05
B-9	3-28-90	316	22	8.00	2.000	1.000	0.063	27.84	14.2289	14.2290	-0.0001	24.00	-7.37E-06	
150 deg. F First regeneration test at 0.75 lb/gal of 1.58 oz Ni/gal loaded solution pH-10.25 Mechanical Agitation														
B-9	3-30-90	Ni-S	356	8.90	2.000	1.000	0.063	27.84	22.1739	21.7707	0.4032	1.00	6.41E-01	6.16E-01
B-9	3-30-90	Ni-S	364	8.90	2.000	1.000	0.063	27.84	23.0217	22.6496	0.3721	1.00	5.91E-01	
B-9	3-30-90	Ni-P	086	8.90	2.000	1.000	0.063	27.84	18.9464	18.6722	0.2742	1.00	4.36E-01	4.61E-01
B-9	3-30-90	Ni-P	107	8.90	2.000	1.000	0.063	27.84	19.2650	18.9584	0.3066	1.00	4.87E-01	
B-9	3-30-90	Ni-S	392	8.90	2.000	1.000	0.063	27.84	21.4588	20.6939	0.7649	2.00	6.08E-01	5.99E-01
B-9	3-30-90	Ni-S	419	8.90	2.000	1.000	0.063	27.84	24.4176	23.6748	0.7428	2.00	5.90E-01	
B-9	3-30-90	Ni-P	137	8.90	2.000	1.000	0.063	27.84	19.0996	18.5766	0.5230	2.00	4.16E-01	4.08E-01
B-9	3-30-90	Ni-P	157	8.90	2.000	1.000	0.063	27.84	18.7943	18.2900	0.5043	2.00	4.01E-01	
B-9	3-30-90	Ni-S	423	8.90	2.000	1.000	0.063	27.84	22.6928	21.3012	1.3916	4.00	5.53E-01	5.40E-01
B-9	3-30-90	Ni-S	550	8.90	2.000	1.000	0.063	27.84	23.6363	22.3102	1.3261	4.00	5.27E-01	
B-9	3-30-90	Ni-P	159	8.90	2.000	1.000	0.063	27.84	18.7301	17.9798	0.7503	4.00	2.98E-01	2.90E-01

Stripper	Test Date	Coupon Material	Coupon #	Density (g/cm3)	Unmasked Dimensions in inches length	width	thick	Surface Area (cm2)	Initial Mass (grams)	Final Mass (grams)	Change Mass (grams)	Total Time (hours)	Stripping Rate (mil/hour)	Average S.R. (mil/hr)
B-9	3-30-90	Ni-P	195	8.90	2.000	1.000	0.063	27.84	18.5834	17.8720	0.7114	4.00	2.83E-01	
150 deg. F	Mechanical Agitation	First test – Rate vs pH	pH-9.62											
B-9	6-29-90	Ni-S	352	8.90	2.045	1.040	0.083	30.19	22.2655	21.1521	1.1134	1.00	1.63E+00	1.62E+00
B-9	6-29-90	Ni-S	413	8.90	2.049	1.039	0.092	30.52	23.5087	22.4057	1.1030	1.00	1.60E+00	
B-9	6-29-90	Ni-P	153	8.90	2.029	1.014	0.075	29.00	18.9626	18.1736	0.7890	1.00	1.20E+00	1.21E+00
B-9	6-29-90	Ni-P	154	8.90	2.029	1.013	0.075	28.97	18.9362	18.1403	0.7959	1.00	1.22E+00	
B-9	6-29-90	Ni-S	482	8.90	2.037	1.040	0.079	29.94	21.9215	20.3937	1.5278	2.00	1.13E+00	1.14E+00
B-9	6-29-90	Ni-S	514	8.90	2.045	1.041	0.083	30.22	22.3666	20.7874	1.5792	2.00	1.16E+00	
B-9	6-29-90	Ni-P	189	8.90	2.021	1.012	0.074	28.80	18.6212	17.6243	0.9969	2.00	7.66E-01	7.81E-01
B-9	6-29-90	Ni-P	255	8.90	2.022	1.014	0.074	28.87	18.6611	17.6225	1.0386	2.00	7.96E-01	
B-9	6-29-90	Ni-S	517	8.90	2.046	1.045	0.085	30.41	22.6058	19.8482	2.7576	4.00	1.00E+00	1.04E+00
B-9	6-29-90	Ni-S	571	8.90	2.046	1.043	0.083	30.28	22.2777	19.3350	2.9427	4.00	1.07E+00	
B-9	6-29-90	Ni-P	292	8.90	2.019	1.015	0.075	28.89	18.8579	16.8492	2.0087	4.00	7.69E-01	7.48E-01
B-9	6-29-90	Ni-P	295	8.90	2.021	1.015	0.074	28.88	18.6877	16.7909	1.8968	4.00	7.26E-01	
150 deg. F	Mechanical Agitation	Second test – Rate vs pH	pH-10.10											
B-9	6-30-90	Ni-S	312	8.90	2.035	1.042	0.083	30.10	22.1996	21.5281	0.6715	1.00	9.87E-01	1.03E+00
B-9	6-30-90	Ni-S	345	8.90	2.036	1.026	0.078	29.52	20.8432	20.1279	0.7153	1.00	1.07E+00	
B-9	6-30-90	Ni-P	001	8.90	2.022	1.013	0.076	28.91	19.1789	18.6631	0.5158	1.00	7.89E-01	7.64E-01
B-9	6-30-90	Ni-P	028	8.90	2.017	1.012	0.074	28.75	18.7066	18.2269	0.4797	1.00	7.38E-01	
B-9	6-30-90	Ni-S	496	8.90	2.042	1.036	0.081	29.97	21.8064	20.6445	1.1619	2.00	8.57E-01	9.17E-01
B-9	6-30-90	Ni-S	590	8.90	2.037	1.042	0.082	30.09	22.1757	20.8463	1.3294	2.00	9.77E-01	
B-9	6-30-90	Ni-P	090	8.90	2.032	1.010	0.075	28.94	18.8115	17.9564	0.8551	2.00	6.54E-01	7.14E-01
B-9	6-30-90	Ni-P	158	8.90	2.023	1.014	0.074	28.88	18.8510	17.8400	1.0110	2.00	7.74E-01	
B-9	6-30-90	Ni-S	599	8.90	2.035	1.036	0.080	29.84	21.6097	19.6102	1.9995	4.00	7.41E-01	7.60E-01
B-9	6-30-90	Ni-S	600	8.90	2.038	1.046	0.082	30.22	21.8806	19.7526	2.1280	4.00	7.79E-01	
B-9	6-30-90	Ni-P	177	8.90	2.018	1.013	0.074	28.79	18.6443	17.1560	1.4883	4.00	5.72E-01	5.97E-01
B-9	6-30-90	Ni-P	251	8.90	2.020	1.014	0.075	28.87	18.6897	17.0670	1.6227	4.00	6.21E-01	
150 deg. F	Mechanical Agitation	Third test – Rate vs pH	pH-10.62											
B-9	7-1-90	Ni-S	330	8.90	2.043	1.028	0.076	29.61	21.0971	20.5281	0.5690	1.00	8.50E-01	8.27E-01
B-9	7-1-90	Ni-S	382	8.90	2.046	1.037	0.080	30.02	22.1986	21.6527	0.5459	1.00	8.04E-01	
B-9	7-1-90	Ni-P	003	8.90	2.023	1.013	0.075	28.89	19.0251	18.6402	0.3849	1.00	5.89E-01	6.00E-01
B-9	7-1-90	Ni-P	085	8.90	2.031	1.013	0.075	29.00	18.9560	18.5558	0.4002	1.00	6.10E-01	
B-9	7-1-90	Ni-S	384	8.90	2.038	1.040	0.079	29.96	22.6028	21.7058	0.8970	2.00	6.62E-01	6.86E-01
B-9	7-1-90	Ni-S	453	8.90	2.040	1.045	0.082	30.22	23.6992	22.7287	0.9705	2.00	7.10E-01	
B-9	7-1-90	Ni-P	100	8.90	2.029	1.014	0.074	28.97	18.8628	18.2008	0.6620	2.00	5.05E-01	5.32E-01
B-9	7-1-90	Ni-P	138	8.90	2.023	1.015	0.076	28.98	19.2004	18.4697	0.7307	2.00	5.58E-01	
B-9	7-1-90	Ni-S	572	8.90	2.043	1.040	0.082	30.13	22.3017	20.7154	1.5863	4.00	5.82E-01	5.80E-01
B-9	7-1-90	Ni-S	575	8.90	2.044	1.040	0.081	30.11	22.2778	20.7028	1.5750	4.00	5.78E-01	
B-9	7-1-90	Ni-P	216	8.90	2.024	1.012	0.075	28.88	18.8426	17.4582	1.3844	4.00	5.30E-01	5.01E-01
B-9	7-1-90	Ni-P	291	8.90	2.015	1.012	0.075	28.75	18.7593	17.5322	1.2271	4.00	4.72E-01	

Stripper	Test Date	Coupon Material	Coupon #	Density (g/cm3)	Unmasked Dimensions in inches length	width	thick	Surface Area (cm2)	Initial Mass (grams)	Final Mass (grams)	Change Mass (grams)	Total Time (hours)	Stripping Rate (mil/hour)	Average S.R. (mil/hr)
150 deg. F Mechanical Agitation Basis metals protection test – Strip rate vs pH pH–10.62														
B–9	6–30–90	C4340	78	7.84	2.010	0.998	0.062	27.89	15.0094	15.0088	0.0006	24.00	4.50E–05	4.51E–05
B–9	6–30–90	C4340	86	7.84	2.008	0.998	0.061	27.83	14.8484	14.8478	0.0006	24.00	4.51E–05	
B–9	6–30–90	D6AC	87	8.20	2.027	1.032	0.078	29.55	19.9166	19.9162	0.0004	24.00	2.71E–05	4.15E–05
B–9	6–30–90	D6AC	90	8.20	2.000	1.012	0.078	28.64	17.9674	17.9666	0.0008	24.00	5.59E–05	
B–9	6–30–90	321	113	7.92	2.018	1.015	0.062	28.45	15.3890	15.3885	0.0005	24.00	3.64E–05	1.09E–05
B–9	6–30–90	321	114	7.92	2.022	1.005	0.062	28.24	15.4940	15.4942	–0.0002	24.00	–1.47E–05	
B–9	6–30–90	718	046	8.60	2.003	1.000	0.063	27.88	16.3330	16.3329	0.0001	24.00	6.84E–06	–3.40E–06
B–9	6–30–90	718	047	8.60	2.009	1.000	0.063	27.96	16.2439	16.2441	–0.0002	24.00	–1.36E–05	
B–9	6–30–90	HA188	044	9.70	2.018	1.000	0.060	27.99	16.9187	16.9186	0.0001	24.00	6.04E–06	1.81E–05
B–9	6–30–90	HA188	047	9.70	2.019	1.000	0.059	27.97	17.0357	17.0352	0.0005	24.00	3.02E–05	
B–9	6–30–90	316	008	8.00	2.020	1.018	0.057	28.39	14.4893	14.4892	0.0001	24.00	7.22E–06	3.61E–06
B–9	6–30–90	316	009	8.00	2.019	1.021	0.057	28.46	14.4195	14.4195	0.0000	24.00	0.00E+00	
B–9	6–30–90	17–4PH	01	7.80	2.007	1.005	0.062	28.03	14.8507	14.8507	0.0000	24.00	0.00E+00	7.48E–06
B–9	6–30–90	17–4PH	02	7.80	2.004	1.009	0.063	28.13	15.2584	15.2582	0.0002	24.00	1.50E–05	
Second regeneration Regenerated w/ 0.75 pds/gal total regeneration 1.5 pds/ gal on 1.58 oz Ni/gal loaded solution pH–10.26 150 deg. F														
B–9	6–18–90	410	127	7.70	2.020	1.013	0.060	28.36	14.4579	14.4571	0.0008	24.00	6.01E–05	1.45E–04
B–9	6–18–90	410	130	7.70	2.018	1.025	0.060	28.65	14.6896	14.6865	0.0031	24.00	2.31E–04	
B–9	6–18–90	C4340	66	7.84	2.011	0.998	0.062	27.90	14.7799	14.7783	0.0016	24.00	1.20E–04	1.08E–04
B–9	6–18–90	C4340	67	7.84	2.022	1.000	0.062	28.11	14.8035	14.8022	0.0013	24.00	9.68E–05	
B–9	6–18–90	D6AC	64	8.20	2.028	1.010	0.074	28.85	17.2638	17.2630	0.0008	24.00	5.55E–05	1.10E–04
B–9	6–18–90	D6AC	65	8.20	2.036	1.010	0.078	29.09	18.6536	18.6512	0.0024	24.00	1.65E–04	
B–9	6–18–90	321	109	7.92	2.014	1.005	0.063	28.16	15.1837	15.1812	0.0025	24.00	1.84E–04	1.21E–04
B–9	6–18–90	321	110	7.92	2.013	1.004	0.063	28.12	15.3067	15.3059	0.0008	24.00	5.89E–05	
B–9	6–18–90	I–718	70	8.60	2.003	1.009	0.063	28.12	16.3627	16.3618	0.0009	24.00	6.11E–05	3.73E–05
B–9	6–18–90	I–718	71	8.60	2.016	1.001	0.063	28.08	15.9929	15.9927	0.0002	24.00	1.36E–05	
B–9	6–18–90	HA–188	23	9.70	2.022	1.001	0.060	28.07	17.0870	17.0860	0.0010	24.00	6.02E–05	5.74E–05
B–9	6–18–90	HA–188	24	9.70	2.012	0.999	0.060	27.88	16.9206	16.9197	0.0009	24.00	5.46E–05	
B–9	6–18–90	316	04	8.00	2.020	1.020	0.058	28.48	14.6650	14.6638	0.0012	24.00	8.64E–05	7.93E–05
B–9	6–18–90	316	05	8.00	2.017	1.018	0.058	28.38	14.6133	14.6123	0.0010	24.00	7.22E–05	
Second regeneration Regenerated a total of 1.5 pds/gal of 1.58 oz Ni/gal loaded solution pH–10.26 150 deg. F														
B–9	6–18–90	Ni–S	331	8.90	2.039	1.033	0.076	29.68	21.4394	21.0351	0.4043	1.00	6.03E–01	5.64E–01
B–9	6–18–90	Ni–S	351	8.90	2.037	1.041	0.077	29.90	21.8505	21.4956	0.3549	1.00	5.25E–01	
B–9	6–18–90	Ni–P	004	8.90	2.018	1.012	0.076	28.83	19.0465	18.8124	0.2341	1.00	3.59E–01	3.59E–01
B–9	6–18–90	Ni–P	043	8.90	2.020	1.015	0.076	28.93	18.8320	18.5974	0.2346	1.00	3.59E–01	
B–9	6–18–90	Ni–S	354	8.90	2.050	1.042	0.080	30.22	22.9903	22.0121	0.9782	2.00	7.16E–01	7.10E–01
B–9	6–18–90	Ni–S	487	8.90	2.052	1.045	0.080	30.33	22.9523	21.9861	0.9662	2.00	7.05E–01	
B–9	6–18–90	Ni–P	072	8.90	2.032	1.011	0.076	29.00	18.8719	18.4575	0.4144	2.00	3.16E–01	4.10E–01
B–9	6–18–90	Ni–P	076	8.90	2.019	1.017	0.076	28.97	19.1912	18.5306	0.6606	2.00	5.04E–01	
B–9	6–18–90	Ni–S	489	8.90	2.042	1.045	0.080	30.18	22.5844	21.2615	1.3229	4.00	4.85E–01	4.89E–01
B–9	6–18–90	Ni–S	507	8.90	2.025	1.042	0.078	29.79	21.5958	20.2689	1.3269	4.00	4.93E–01	
B–9	6–18–90	Ni–P	150	8.90	2.021	1.013	0.075	28.86	18.7488	18.1110	0.6378	4.00	2.44E–01	2.58E–01
B–9	6–18–90	Ni–P	238	8.90	2.015	1.012	0.073	28.69	18.3387	17.6336	0.7051	4.00	2.72E–01	

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APPENDIX F

STRIPPING RATE DATA FOR THE FIELD TESTING OF M&T HARSHAW'S NI-PLEX 100 STRIPPER

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Stripper	Test Date	Coupon Material	Coupon #	Density (g/cm3)	Unmasked Dimensions in inches length	width	thick	Surface Area (cm2)	Initial Mass (grams)	Final Mass (grams)	Change Mass (grams)	Total Time (hours)	Stripping Rate (mil/hr)	Average S.R. (mil/hr)
140 deg. F	Small Tank	pH-9.72	Agitation	Fresh Solution										
NiPlex100	8-22-89	410	34	7.70	1.469	1.000	0.063	20.54	17.7072	17.7072	0.0000	24.00	0.00E+00	-3.63E-05
NiPlex100	8-22-89	410	33	7.70	1.469	1.000	0.063	20.54	17.8291	17.8298	-0.0007	24.00	-7.26E-05	
NiPlex100	8-22-89	C4340	113	7.84	1.500	1.000	0.063	20.97	15.2315	15.2315	0.0000	24.00	0.00E+00	-5.09E-06
NiPlex100	8-22-89	C4340	112	7.84	1.469	1.000	0.063	20.54	15.0709	15.0710	-0.0001	24.00	-1.02E-05	
NiPlex100	8-22-89	D6AC	34	8.20	1.469	1.000	0.094	21.34	18.0528	18.0524	0.0004	24.00	3.75E-05	1.40E-05
NiPlex100	8-22-89	D6AC	31	8.20	1.438	1.000	0.094	20.90	20.2738	20.2739	-0.0001	24.00	-9.57E-06	
NiPlex100	8-22-89	321	41	7.92	1.469	1.000	0.063	20.54	15.0751	15.0755	-0.0004	24.00	-4.03E-05	-5.87E-05
NiPlex100	8-22-89	321	45	7.92	1.344	1.000	0.063	18.83	15.4362	15.4369	-0.0007	24.00	-7.70E-05	
NiPlex100	8-22-89	I-718	119	8.60	1.469	1.000	0.063	20.54	16.1515	16.1517	-0.0002	24.00	-1.86E-05	-4.64E-06
NiPlex100	8-22-89	I-718	120	8.60	1.469	1.000	0.063	20.54	15.9660	15.9659	0.0001	24.00	9.29E-06	
NiPlex100	8-22-89	HA188	91	9.70	1.500	1.000	0.063	20.97	16.9155	16.9155	0.0000	24.00	0.00E+00	4.11E-06
NiPlex100	8-22-89	HA188	92	9.70	1.469	1.000	0.063	20.55	17.1979	17.1978	0.0001	24.00	8.23E-06	
NiPlex100	8-22-89	Cu	90	8.92	1.438	1.000	0.125	21.67	29.5497	29.5397	0.0100	1.00	2.04E-02	1.76E-02
NiPlex100	8-22-89	Cu	99	8.92	1.438	1.000	0.125	21.67	28.2570	28.2497	0.0073	1.00	1.49E-02	
NiPlex100	8-22-89	Ni-S	315	8.90	1.500	1.000	0.063	20.97	21.5711	21.1151	0.4560	1.00	9.62E-01	9.04E-01
NiPlex100	8-22-89	Ni-S	368	8.90	1.469	1.000	0.063	20.54	23.2036	22.8105	0.3931	1.00	8.47E-01	
NiPlex100	8-22-89	Ni-P	110	8.90	1.344	1.000	0.063	18.83	18.1183	17.9658	0.1525	1.00	3.58E-01	4.29E-01
NiPlex100	8-22-89	Ni-P	293	8.90	1.469	1.000	0.063	20.54	18.9703	18.7387	0.2316	1.00	4.99E-01	
150 deg. F	Small Tank	pH-9.72												
NiPlex100	11-1-89	410	149	7.70	1.500	1.000	0.063	20.97	14.4043	14.4036	0.0007	24.00	7.11E-05	5.59E-05
NiPlex100	11-1-89	410	150	7.70	1.500	1.000	0.063	20.97	14.2849	14.2845	0.0004	24.00	4.06E-05	
NiPlex100	11-1-89	C4340	107	7.84	1.500	1.000	0.063	20.97	14.8347	14.8351	-0.0004	24.00	-3.99E-05	4.99E-06
NiPlex100	11-1-89	C4340	108	7.84	1.500	1.000	0.063	20.97	14.9000	14.8995	0.0005	24.00	4.99E-05	
NiPlex100	11-1-89	D6AC	40	8.20	1.500	1.000	0.094	21.78	18.9065	18.9056	0.0009	24.00	8.27E-05	9.64E-05
NiPlex100	11-1-89	D6AC	37	8.20	1.500	1.000	0.094	21.78	17.9360	17.9348	0.0012	24.00	1.10E-04	
NiPlex100	11-1-89	321	46	7.92	1.500	1.000	0.063	20.97	14.7230	14.7222	0.0008	24.00	7.90E-05	7.41E-05
NiPlex100	11-1-89	321	47	7.92	1.500	1.000	0.063	20.97	14.9864	14.9857	0.0007	24.00	6.91E-05	
NiPlex100	11-1-89	I-718	109	8.60	1.500	1.000	0.063	20.97	16.1090	16.1087	0.0003	24.00	2.73E-05	2.73E-05
NiPlex100	11-1-89	I-718	110	8.60	1.500	1.000	0.063	20.97	16.1470	16.1467	0.0003	24.00	2.73E-05	
NiPlex100	11-1-89	HA188	10	9.70	1.500	1.000	0.063	20.97	16.4613	16.4610	0.0003	24.00	2.42E-05	2.82E-05
NiPlex100	11-1-89	HA188	13	9.70	1.500	1.000	0.063	20.98	17.1965	17.1961	0.0004	24.00	3.22E-05	
NiPlex100	11-1-89	316	18	8.03	1.500	1.000	0.063	20.98	14.6217	14.6213	0.0004	24.00	3.89E-05	3.41E-05
NiPlex100	11-1-89	316	19	8.03	1.500	1.000	0.063	20.98	13.8896	13.8893	0.0003	24.00	2.92E-05	
NiPlex100	11-1-89	Cu	7	8.92	1.500	1.000	0.125	22.58	28.8678	28.8316	0.0362	1.00	7.08E-02	5.41E-02
NiPlex100	11-1-89	Cu	74	8.92	1.500	1.000	0.125	22.58	27.8162	27.7970	0.0192	1.00	3.75E-02	
NiPlex100	11-1-89	Ni-S	317	8.90	1.500	1.000	0.063	20.97	20.4156	19.5930	0.8226	1.00	1.74E+00	2.13E+00
NiPlex100	11-1-89	Ni-S	328	8.90	1.500	1.000	0.063	20.97	22.2934	21.0949	1.1985	1.00	2.53E+00	
NiPlex100	11-1-89	Ni-P	75	8.90	1.500	1.000	0.063	20.97	18.6957	18.1563	0.5394	1.00	1.14E+00	1.18E+00
NiPlex100	11-1-89	Ni-P	128	8.90	1.500	1.000	0.063	20.97	19.0129	18.4305	0.5824	1.00	1.23E+00	
NiPlex100	11-1-89	Cu	36	8.92	1.500	1.000	0.125	22.58	29.1868	29.1430	0.0438	2.00	4.28E-02	3.74E-02
NiPlex100	11-1-89	Cu	44	8.92	1.500	1.000	0.125	22.58	29.0788	29.0460	0.0328	2.00	3.21E-02	
NiPlex100	11-1-89	Ni-S	353	8.90	1.500	1.000	0.063	20.97	21.5602	20.1425	1.4177	2.00	1.50E+00	1.51E+00
NiPlex100	11-1-89	Ni-S	311	8.90	1.500	1.000	0.063	20.97	22.6176	21.1738	1.4438	2.00	1.52E+00	
NiPlex100	11-1-89	Ni-P	180	8.90	1.500	1.000	0.063	20.97	18.5702	17.3072	1.2630	2.00	1.33E+00	1.13E+00
NiPlex100	11-1-89	Ni-P	27	8.90	1.500	1.000	0.063	20.97	18.5866	17.7102	0.8764	2.00	9.24E-01	

Stripper	Test Date	Coupon Material	Coupon #	Density (g/cm3)	Unmasked Dimensions in inches length	width	thick	Surface Area (cm2)	Initial Mass (grams)	Final Mass (grams)	Change Mass (grams)	Total Time (hours)	Stripping Rate (mil/hr)	Average S.R. (mil/hr)
NiPlex100	11-1-89	Cu	76	8.92	1.500	1.000	0.125	22.58	28.8127	28.7226	0.0901	4.00	4.40E-02	3.95E-02
NiPlex100	11-1-89	Cu	77	8.92	1.500	1.000	0.125	22.58	27.3820	27.3103	0.0717	4.00	3.50E-02	
NiPlex100	11-1-89	Ni-S	463	8.90	1.500	1.000	0.063	20.97	24.6180	22.2145	2.4035	4.00	1.27E+00	1.27E+00
NiPlex100	11-1-89	Ni-S	349	8.90	1.500	1.000	0.063	20.97	22.6249	20.2310	2.3939	4.00	1.26E+00	
NiPlex100	11-1-89	Ni-P	218	8.90	1.500	1.000	0.063	20.97	18.8139	17.3747	1.4392	4.00	7.59E-01	8.10E-01
NiPlex100	11-1-89	Ni-P	16	8.90	1.500	1.000	0.063	20.97	19.0591	17.4266	1.6325	4.00	8.61E-01	
120 deg. F Small Tank pH-10.0														
NiPlex100	8-25-89	410	35	7.70	1.375	1.000	0.063	19.25	17.6720	17.6721	-0.0001	24.00	-1.11E-05	-2.25E-05
NiPlex100	8-25-89	410	36	7.70	1.344	1.000	0.063	18.83	17.8885	17.8888	-0.0003	24.00	-3.39E-05	
NiPlex100	8-25-89	C4340	110	7.84	1.469	1.000	0.063	20.54	14.8599	14.8598	0.0001	24.00	1.02E-05	-4.64E-07
NiPlex100	8-25-89	C4340	111	7.84	1.344	1.000	0.063	18.83	14.6685	14.6686	-0.0001	24.00	-1.11E-05	
NiPlex100	8-25-89	D6AC	28	8.20	1.344	1.000	0.094	19.57	20.0828	20.0821	0.0007	24.00	7.15E-05	5.45E-05
NiPlex100	8-25-89	D6AC	33	8.20	1.469	1.000	0.094	21.34	19.7263	19.7259	0.0004	24.00	3.75E-05	
NiPlex100	8-25-89	321	38	7.92	1.438	1.000	0.063	20.11	15.2430	15.2434	-0.0004	24.00	-4.12E-05	-2.06E-05
NiPlex100	8-25-89	321	40	7.92	1.438	1.000	0.063	20.11	15.1133	15.1133	0.0000	24.00	0.00E+00	
NiPlex100	8-25-89	I-718	118	8.60	1.438	1.000	0.063	20.11	15.8779	15.8777	0.0002	24.00	1.90E-05	4.84E-06
NiPlex100	8-25-89	I-718	122	8.60	1.469	1.000	0.063	20.54	16.1010	16.1011	-0.0001	24.00	-9.29E-06	
NiPlex100	8-25-89	HA188	87	9.70	1.469	1.000	0.063	20.54	17.3137	17.3137	0.0000	24.00	0.00E+00	8.23E-06
NiPlex100	8-25-89	HA188	90	9.70	1.469	1.000	0.063	20.55	16.8076	16.8074	0.0002	24.00	1.65E-05	
NiPlex100	8-25-89	Cu	96	8.92	1.406	1.000	0.125	21.22	27.8591	27.8487	0.0104	1.00	2.16E-02	2.36E-02
NiPlex100	8-25-89	Cu	97	8.92	1.438	1.000	0.125	21.67	29.0916	29.0790	0.0126	1.00	2.57E-02	
NiPlex100	8-25-89	Ni-S	497	8.90	1.500	1.000	0.063	20.97	22.4409	22.1250	0.3159	1.00	6.66E-01	6.95E-01
NiPlex100	8-25-89	Ni-S	516	8.90	1.500	1.000	0.063	20.97	22.5062	22.1630	0.3432	1.00	7.24E-01	
NiPlex100	8-25-89	Ni-P	92	8.90	1.469	1.000	0.063	20.54	18.9537	18.7771	0.1766	1.00	3.80E-01	3.32E-01
NiPlex100	8-25-89	Ni-P	236	8.90	1.500	1.000	0.063	20.97	18.6505	18.5164	0.1341	1.00	2.83E-01	
150 deg. F Small Tank pH-10.3 Loaded with 1 oz Ni/gal														
NiPlex100	11-17-89	410	148	7.70	1.500	1.000	0.063	20.97	14.4520	14.4530	-0.0010	24.00	-1.02E-04	-1.02E-04
NiPlex100	11-17-89	410	147	7.70	1.500	1.000	0.063	20.97	14.4498	14.4508	-0.0010	24.00	-1.02E-04	
NiPlex100	11-17-89	C4340	48	7.84	1.500	1.000	0.063	20.97	14.9184	14.9191	-0.0007	24.00	-6.99E-05	-5.49E-05
NiPlex100	11-17-89	C4340	49	7.84	1.500	1.000	0.063	20.97	14.8655	14.8659	-0.0004	24.00	-3.99E-05	
NiPlex100	11-17-89	D6AC	30	8.20	1.500	1.000	0.094	21.78	17.2378	17.2382	-0.0004	24.00	-3.67E-05	-4.59E-05
NiPlex100	11-17-89	D6AC	45	8.20	1.500	1.000	0.094	21.78	17.9786	17.9792	-0.0006	24.00	-5.51E-05	
NiPlex100	11-17-89	321	59	7.92	1.500	1.000	0.063	20.97	15.1979	15.1592	0.0387	24.00	3.82E-03	1.85E-03
NiPlex100	11-17-89	321	60	7.92	1.500	1.000	0.063	20.97	15.3602	15.3615	-0.0013	24.00	-1.28E-04	
NiPlex100	11-17-89	I-718	106	8.60	1.500	1.000	0.063	20.97	16.1426	16.1436	-0.0010	24.00	-9.10E-05	-9.10E-05
NiPlex100	11-17-89	I-718	111	8.60	1.500	1.000	0.063	20.97	16.2099	16.2109	-0.0010	24.00	-9.10E-05	
NiPlex100	11-17-89	HA188	8	9.70	1.500	1.000	0.063	20.97	16.8414	16.8423	-0.0009	24.00	-7.26E-05	-9.67E-05
NiPlex100	11-17-89	HA188	9	9.70	1.500	1.000	0.063	20.98	16.9539	16.9554	-0.0015	24.00	-1.21E-04	
NiPlex100	11-17-89	316	20	8.03	1.500	1.000	0.063	20.98	14.4808	14.4815	-0.0007	24.00	-6.82E-05	-7.30E-05
NiPlex100	11-17-89	316	23	8.03	1.500	1.000	0.063	20.98	14.3708	14.3716	-0.0008	24.00	-7.79E-05	
NiPlex100	11-17-89	Ni-S	439	8.90	1.500	1.000	0.063	20.97	23.9726	23.5779	0.3947	1.00	8.33E-01	9.40E-01
NiPlex100	11-17-89	Ni-S	399	8.90	1.500	1.000	0.063	20.97	21.4953	20.9993	0.4960	1.00	1.05E+00	
NiPlex100	11-17-89	Ni-P	58	8.90	1.500	1.000	0.063	20.97	18.8088	18.5898	0.2190	1.00	4.62E-01	4.92E-01
NiPlex100	11-17-89	Ni-P	91	8.90	1.500	1.000	0.063	20.97	19.1145	18.8674	0.2471	1.00	5.21E-01	
NiPlex100	11-17-89	Ni-S	549	8.90	1.500	1.000	0.063	20.97	21.6753	21.0834	0.5919	2.00	6.24E-01	5.68E-01

Stripper	Test Date	Coupon Material	Coupon #	Density (g/cm3)	Unmasked Dimensions in inches length	width	thick	Surface Area (cm2)	Initial Mass (grams)	Final Mass (grams)	Change Mass (grams)	Total Time (hours)	Stripping Rate (mil/hr)	Average S.R. (mil/hr)
NiPlex100	11-17-89	Ni-S	495	8.90	1.500	1.000	0.063	20.97	22.0425	21.5566	0.4859	2.00	5.13E-01	
NiPlex100	11-17-89	Ni-P	140	8.90	1.500	1.000	0.063	20.97	19.2313	18.8578	0.3735	2.00	3.94E-01	3.54E-01
NiPlex100	11-17-89	Ni-P	142	8.90	1.500	1.000	0.063	20.97	18.8254	18.5283	0.2971	2.00	3.13E-01	
NiPlex100	11-17-89	Ni-S	393	8.90	1.500	1.000	0.063	20.97	21.7306	20.4149	1.3157	4.00	6.94E-01	7.09E-01
NiPlex100	11-17-89	Ni-S	405	8.90	1.500	1.000	0.063	20.97	25.8274	24.4533	1.3741	4.00	7.25E-01	
NiPlex100	11-17-89	Ni-P	198	8.90	1.500	1.000	0.063	20.97	18.9241	18.0924	0.8317	4.00	4.39E-01	3.99E-01
NiPlex100	11-17-89	Ni-P	142	8.90	1.500	1.000	0.063	20.97	18.3689	17.6862	0.6827	4.00	3.60E-01	
150 deg. F Small Tank pH-10.3 Loaded with approx. 2 oz Ni/gal														
NiPlex100	11-21-89	410	148	7.70	2.000	1.000	0.063	27.82	14.4498	14.4496	0.0002	24.00	1.53E-05	1.91E-05
NiPlex100	11-21-89	410	147	7.70	2.000	1.000	0.063	27.82	14.4521	14.4518	0.0003	24.00	2.30E-05	
NiPlex100	11-21-89	C4340	48	7.84	2.000	1.000	0.063	27.82	14.9184	14.9170	0.0014	24.00	1.05E-04	7.90E-05
NiPlex100	11-21-89	C4340	49	7.84	2.000	1.000	0.063	27.82	14.8650	14.8643	0.0007	24.00	5.26E-05	
NiPlex100	11-21-89	D6AC	45	8.20	2.000	1.000	0.094	28.84	17.9778	17.9775	0.0003	24.00	2.08E-05	4.16E-05
NiPlex100	11-21-89	D6AC	30	8.20	2.000	1.000	0.094	28.84	17.2374	17.2365	0.0009	24.00	6.24E-05	
NiPlex100	11-21-89	321	59	7.92	2.000	1.000	0.063	27.82	15.1980	15.1978	0.0002	24.00	1.49E-05	1.49E-05
NiPlex100	11-21-89	321	60	7.92	2.000	1.000	0.063	27.82	15.3605	15.3603	0.0002	24.00	1.49E-05	
NiPlex100	11-21-89	I-718	111	8.60	2.000	1.000	0.063	27.82	16.2097	16.2093	0.0004	24.00	2.74E-05	2.06E-05
NiPlex100	11-21-89	I-718	106	8.60	2.000	1.000	0.063	27.82	16.1420	16.1418	0.0002	24.00	1.37E-05	
NiPlex100	11-21-89	HA 188	9	9.70	2.000	1.000	0.063	27.82	16.9545	16.9540	0.0005	24.00	3.04E-05	2.13E-05
NiPlex100	11-21-89	HA 188	8	9.70	2.000	1.000	0.063	27.84	16.8409	16.8407	0.0002	24.00	1.21E-05	
NiPlex100	11-21-89	316	20	8.03	2.000	1.000	0.063	27.84	14.4800	14.4804	-0.0004	24.00	-2.94E-05	-2.20E-05
NiPlex100	11-21-89	316	23	8.03	2.000	1.000	0.063	27.84	14.3700	14.3702	-0.0002	24.00	-1.47E-05	
NiPlex100	11-21-89	Ni-S	595	8.90	2.000	1.000	0.063	27.82	23.0062	22.9600	0.0462	1.00	7.35E-02	7.44E-02
NiPlex100	11-21-89	Ni-S	582	8.90	2.000	1.000	0.063	27.82	23.3590	23.3116	0.0474	1.00	7.54E-02	
NiPlex100	11-21-89	Ni-P	151	8.90	2.000	1.000	0.063	27.82	19.0003	18.9763	0.0240	1.00	3.82E-02	3.59E-02
NiPlex100	11-21-89	Ni-P	23	8.90	2.000	1.000	0.063	27.82	19.1081	19.0869	0.0212	1.00	3.37E-02	
NiPlex100	11-21-89	Ni-S	597	8.90	2.000	1.000	0.063	27.82	21.7821	21.6705	0.1116	2.00	8.87E-02	9.02E-02
NiPlex100	11-21-89	Ni-S	522	8.90	2.000	1.000	0.063	27.82	25.2115	25.0962	0.1153	2.00	9.17E-02	
NiPlex100	11-21-89	Ni-P	117	8.90	2.000	1.000	0.063	27.82	18.7243	18.6699	0.0544	2.00	4.32E-02	4.55E-02
NiPlex100	11-21-89	Ni-P	111	8.90	2.000	1.000	0.063	27.82	19.0340	18.9740	0.0600	2.00	4.77E-02	
NiPlex100	11-21-89	Ni-S	309	8.90	2.000	1.000	0.063	27.82	23.8446	23.5879	0.2567	4.00	1.02E-01	1.07E-01
NiPlex100	11-21-89	Ni-S	424	8.90	2.000	1.000	0.063	27.82	21.6935	21.4094	0.2841	4.00	1.13E-01	
NiPlex100	11-21-89	Ni-P	124	8.90	2.000	1.000	0.063	27.82	19.1355	18.9742	0.1613	4.00	6.41E-02	6.40E-02
NiPlex100	11-21-89	Ni-P	276	8.90	2.000	1.000	0.063	27.82	18.8942	18.7337	0.1605	4.00	6.38E-02	
150 deg. F Small Tank pH-10.3 Mechanical Agitation Regenerated solution with 1 pound Niplex 100/gal														
NiPlex100	12-27-89	410	147	7.70	2.000	1.000	0.063	27.84	14.4518	14.4520	-0.0002	24.00	-1.53E-05	-1.91E-05
NiPlex100	12-27-89	410	148	7.70	2.000	1.000	0.063	27.84	14.4496	14.4499	-0.0003	24.00	-2.30E-05	
NiPlex100	12-27-89	C4340	048	7.84	2.000	1.000	0.063	27.84	14.9170	14.9176	-0.0006	24.00	-4.51E-05	-4.13E-05
NiPlex100	12-27-89	C4340	049	7.84	2.000	1.000	0.063	27.84	14.8643	14.8648	-0.0005	24.00	-3.76E-05	
NiPlex100	12-27-89	D6AC	030	8.20	2.000	1.000	0.063	27.84	17.2365	17.2363	0.0002	24.00	1.44E-05	-3.59E-06
NiPlex100	12-27-89	D6AC	045	8.20	2.000	1.000	0.063	27.84	17.9775	17.9778	-0.0003	24.00	-2.16E-05	
NiPlex100	12-27-89	321	059	7.92	2.000	1.000	0.063	27.84	15.1978	15.1982	-0.0004	24.00	-2.98E-05	-3.35E-05
NiPlex100	12-27-89	321	060	7.92	2.000	1.000	0.063	27.84	15.3603	15.3608	-0.0005	24.00	-3.72E-05	
NiPlex100	12-27-89	I-718	106	8.60	2.000	1.000	0.063	27.84	16.1418	16.1428	-0.0010	24.00	-6.85E-05	-6.51E-05
NiPlex100	12-27-89	I-718	111	8.60	2.000	1.000	0.063	27.84	16.2093	16.2102	-0.0009	24.00	-6.17E-05	

Stripper	Test Date	Coupon Material	Coupon #	Density (g/cm3)	Unmasked Dimensions in inches length	width	thick	Surface Area (cm2)	Initial Mass (grams)	Final Mass (grams)	Change Mass (grams)	Total Time (hours)	Stripping Rate (mil/hr)	Average S.R. (mil/hr)
NiPlex100	12-27-89	HA 188	008	9.70	2.000	1.000	0.063	27.84	16.8407	16.8414	-0.0007	24.00	-4.25E-05	-3.95E-05
NiPlex100	12-27-89	HA 188	009	9.70	2.000	1.000	0.063	27.84	16.9540	16.9546	-0.0006	24.00	-3.64E-05	
NiPlex100	12-27-89	316	020	8.00	2.000	1.000	0.063	27.84	14.4804	14.4812	-0.0008	24.00	-5.89E-05	-5.89E-05
NiPlex100	12-27-89	316	023	8.00	2.000	1.000	0.063	27.84	14.3702	14.3710	-0.0008	24.00	-5.89E-05	
NiPlex100	12-27-89	Ni-S	464	8.90	2.000	1.000	0.063	27.84	23.3655	22.9819	0.3836	1.00	6.10E-01	5.26E-01
NiPlex100	12-27-89	Ni-S	475	8.90	2.000	1.000	0.063	27.84	22.8642	22.5863	0.2779	1.00	4.42E-01	
NiPlex100	12-27-89	Ni-P	074	8.90	2.000	1.000	0.063	27.84	18.7600	18.6075	0.1525	1.00	2.42E-01	2.72E-01
NiPlex100	12-27-89	Ni-P	186	8.90	2.000	1.000	0.063	27.84	18.6544	18.4649	0.1895	1.00	3.01E-01	
NiPlex100	12-27-89	Ni-S	376	8.90	2.000	1.000	0.063	27.84	23.8318	23.2121	0.6197	2.00	4.92E-01	4.86E-01
NiPlex100	12-27-89	Ni-S	407	8.90	2.000	1.000	0.063	27.84	24.1740	23.5699	0.6041	2.00	4.80E-01	
NiPlex100	12-27-89	Ni-P	056	8.90	2.000	1.000	0.063	27.84	18.9234	18.5819	0.3415	2.00	2.71E-01	2.81E-01
NiPlex100	12-27-89	Ni-P	068	8.90	2.000	1.000	0.063	27.84	19.0089	18.6438	0.3651	2.00	2.90E-01	
NiPlex100	12-27-89	Ni-S	426	8.90	2.000	1.000	0.063	27.84	23.9192	22.9413	0.9779	4.00	3.88E-01	4.12E-01
NiPlex100	12-27-89	Ni-S	445	8.90	2.000	1.000	0.063	27.84	25.0042	23.9092	1.0950	4.00	4.35E-01	
NiPlex100	12-27-89	Ni-P	041	8.90	2.000	1.000	0.063	27.84	19.0247	18.4064	0.6183	4.00	2.46E-01	2.40E-01
NiPlex100	12-27-89	Ni-P	114	8.90	2.000	1.000	0.063	27.84	18.9887	18.3990	0.5897	4.00	2.34E-01	
150 deg. F Small Tank pH-10.2 Mechanical Agitation 2nd Test Regenerated solution with 1 pound Niplex 100/gal 2 oz Ni/gal Loaded														
NiPlex100	1-5-90	Ni-S	466	8.90	2.000	1.000	0.063	27.84	22.5519	22.3328	0.2191	1.00	3.48E-01	3.83E-01
NiPlex100	1-5-90	Ni-S	484	8.90	2.000	1.000	0.063	27.84	22.6703	22.4078	0.2625	1.00	4.17E-01	
NiPlex100	1-5-90	Ni-P	078	8.90	2.000	1.000	0.063	27.84	19.1506	18.9604	0.1902	1.00	3.02E-01	2.60E-01
NiPlex100	1-5-90	Ni-P	165	8.90	2.000	1.000	0.063	27.84	18.7221	18.5847	0.1374	1.00	2.18E-01	
NiPlex100	1-5-90	Ni-S	357	8.90	2.000	1.000	0.063	27.84	21.9332	21.4930	0.4402	2.00	3.50E-01	3.61E-01
NiPlex100	1-5-90	Ni-S	360	8.90	2.000	1.000	0.063	27.84	23.3044	22.8364	0.4680	2.00	3.72E-01	
NiPlex100	1-5-90	Ni-P	234	8.90	2.000	1.000	0.063	27.84	18.7027	18.4827	0.2200	2.00	1.75E-01	1.78E-01
NiPlex100	1-5-90	Ni-P	298	8.90	2.000	1.000	0.063	27.84	18.7816	18.5533	0.2283	2.00	1.81E-01	
NiPlex100	1-5-90	Ni-S	503	8.90	2.000	1.000	0.063	27.84	24.8910	23.9400	0.9510	4.00	3.78E-01	3.83E-01
NiPlex100	1-5-90	Ni-S	506	8.90	2.000	1.000	0.063	27.84	24.9391	23.9614	0.9777	4.00	3.88E-01	
NiPlex100	1-5-90	Ni-P	121	8.90	2.000	1.000	0.063	27.84	19.1419	18.5960	0.5459	4.00	2.17E-01	2.11E-01
NiPlex100	1-5-90	Ni-P	272	8.90	2.000	1.000	0.063	27.84	18.9808	18.4653	0.5155	4.00	2.05E-01	
150 deg. F Small Tank pH-10.2 Mechanical Agitation 1st Test Regenerated solution with 1.5 pound Niplex 100/gal														
NiPlex100	1-17-90	Ni-S	580	8.90	2.000	1.000	0.063	27.84	22.5903	22.0281	0.5622	2.00	4.47E-01	4.78E-01
NiPlex100	1-17-90	Ni-S	512	8.90	2.000	1.000	0.063	27.84	21.7244	21.0822	0.6422	2.00	5.10E-01	
NiPlex100	1-17-90	Ni-P	013	8.90	2.000	1.000	0.063	27.84	18.7726	18.4394	0.3332	2.00	2.65E-01	2.48E-01
NiPlex100	1-17-90	Ni-P	235	8.90	2.000	1.000	0.063	27.84	18.7907	18.5008	0.2899	2.00	2.30E-01	
NiPlex100	1-17-90	Ni-S	408	8.90	2.000	1.000	0.063	27.84	23.0683	21.9844	1.0839	4.00	4.31E-01	4.54E-01
NiPlex100	1-17-90	Ni-S	436	8.90	2.000	1.000	0.063	27.84	23.8017	22.5990	1.2027	4.00	4.78E-01	
NiPlex100	1-17-90	Ni-P	241	8.90	2.000	1.000	0.063	27.84	19.0684	18.3446	0.7238	4.00	2.88E-01	2.57E-01
NiPlex100	1-17-90	Ni-P	164	8.90	2.000	1.000	0.063	27.84	18.6059	18.0375	0.5684	4.00	2.26E-01	
150 deg. F Small Tank pH-10.2 Mechanical Agitation 2nd Test Regenerated solution with 1.5 pound Niplex 100/gal														
NiPlex100	1-17-90	Ni-S	433	8.90	2.000	1.000	0.063	27.84	22.2955	21.7747	0.5208	2.00	4.14E-01	4.05E-01
NiPlex100	1-17-90	Ni-S	548	8.90	2.000	1.000	0.063	27.84	21.6066	21.1070	0.4996	2.00	3.97E-01	
NiPlex100	1-17-90	Ni-P	247	8.90	2.000	1.000	0.063	27.84	18.9474	18.6327	0.3147	2.00	2.50E-01	2.43E-01
NiPlex100	1-17-90	Ni-P	264	8.90	2.000	1.000	0.063	27.84	18.8322	18.5352	0.2970	2.00	2.36E-01	

Stripper	Test Date	Coupon Material	Coupon #	Density (g/cm3)	Unmasked Dimensions in inches length	width	thick	Surface Area (cm2)	Initial Mass (grams)	Final Mass (grams)	Change Mass (grams)	Total Time (hours)	Stripping Rate (mil/hr)	Average S.R. (mil/hr)
NiPlex100	1-17-90	Ni-S	414	8.90	2.000	1.000	0.063	27.84	23.2066	22.2578	0.9488	4.00	3.77E-01	3.76E-01
NiPlex100	1-17-90	Ni-S	459	8.90	2.000	1.000	0.063	27.84	22.6293	21.6865	0.9428	4.00	3.75E-01	
NiPlex100	1-17-90	Ni-P	232	8.90	2.000	1.000	0.063	27.84	18.9092	18.3449	0.5643	4.00	2.24E-01	2.22E-01
NiPlex100	1-17-90	Ni-P	290	8.90	2.000	1.000	0.063	27.84	18.6552	18.1017	0.5535	4.00	2.20E-01	
150 deg. F Small Tank pH-10.3 Mechanical Agitation Regenerated solution with .5 pound Reserval-P/gal														
NiPlex100	1-23-90	410	147	7.70	2.000	1.000	0.063	27.84	14.4530	14.4536	-0.0006	24.00	-4.59E-05	-4.97E-05
NiPlex100	1-23-90	410	148	7.70	2.000	1.000	0.063	27.84	14.4488	14.4495	-0.0007	24.00	-5.36E-05	
NiPlex100	1-23-90	C4340	048	7.84	2.000	1.000	0.063	27.84	14.9176	14.9173	0.0003	24.00	2.25E-05	3.38E-05
NiPlex100	1-23-90	C4340	049	7.84	2.000	1.000	0.063	27.84	14.8648	14.8642	0.0006	24.00	4.51E-05	
NiPlex100	1-23-90	D6AC	030	8.20	2.000	1.000	0.063	27.84	17.2628	17.2599	0.0029	24.00	2.08E-04	2.52E-05
NiPlex100	1-23-90	D6AC	045	8.20	2.000	1.000	0.063	27.84	17.9778	17.9800	-0.0022	24.00	-1.58E-04	
NiPlex100	1-23-90	321	059	7.92	2.000	1.000	0.063	27.84	15.1983	15.1987	-0.0004	24.00	-2.98E-05	-1.86E-05
NiPlex100	1-23-90	321	060	7.92	2.000	1.000	0.063	27.84	15.3608	15.3609	-0.0001	24.00	-7.44E-06	
NiPlex100	1-23-90	I-718	106	8.60	2.000	1.000	0.063	27.84	16.1428	16.1432	-0.0004	24.00	-2.74E-05	-2.06E-05
NiPlex100	1-23-90	I-718	111	8.60	2.000	1.000	0.063	27.84	16.2102	16.2104	-0.0002	24.00	-1.37E-05	
NiPlex100	1-23-90	HA 188	008	9.70	2.000	1.000	0.063	27.84	16.8413	16.8419	-0.0006	24.00	-3.64E-05	-3.04E-05
NiPlex100	1-23-90	HA 188	009	9.70	2.000	1.000	0.063	27.84	16.9546	16.9550	-0.0004	24.00	-2.43E-05	
NiPlex100	1-23-90	316	020	8.00	2.000	1.000	0.063	27.84	14.4812	14.4809	0.0003	24.00	2.21E-05	1.10E-05
NiPlex100	1-23-90	316	023	8.00	2.000	1.000	0.063	27.84	14.3710	14.3710	0.0000	24.00	0.00E+00	
NiPlex100	1-23-90	Ni-S	591	8.90	2.000	1.000	0.063	27.84	22.2125	21.8806	0.3319	1.00	5.27E-01	5.27E-01
NiPlex100	1-23-90	Ni-S	534	8.90	2.000	1.000	0.063	27.84	21.8878	21.5560	0.3318	1.00	5.27E-01	
NiPlex100	1-23-90	Ni-P	063	8.90	2.000	1.000	0.063	27.84	18.7278	18.4607	0.2671	1.00	4.24E-01	3.59E-01
NiPlex100	1-23-90	Ni-P	130	8.90	2.000	1.000	0.063	27.84	18.4450	18.2603	0.1847	1.00	2.93E-01	
NiPlex100	1-23-90	Ni-S	306	8.90	2.000	1.000	0.063	27.84	22.3322	21.6487	0.6835	2.00	5.43E-01	5.41E-01
NiPlex100	1-23-90	Ni-S	500	8.90	2.000	1.000	0.063	27.84	23.3396	22.6600	0.6796	2.00	5.40E-01	
NiPlex100	1-23-90	Ni-P	168	8.90	2.000	1.000	0.063	27.84	18.8347	18.3751	0.4596	2.00	3.65E-01	3.53E-01
NiPlex100	1-23-90	Ni-P	217	8.90	2.000	1.000	0.063	27.84	18.9132	18.4830	0.4302	2.00	3.42E-01	
NiPlex100	1-23-90	Ni-S	320	8.90	2.000	1.000	0.063	27.84	23.1762	21.9863	1.1899	4.00	4.73E-01	4.78E-01
NiPlex100	1-23-90	Ni-S	350	8.90	2.000	1.000	0.063	27.84	26.5942	25.3794	1.2148	4.00	4.83E-01	
NiPlex100	1-23-90	Ni-P	246	8.90	2.000	1.000	0.063	27.84	18.8877	18.1673	0.7204	4.00	2.86E-01	2.63E-01
NiPlex100	1-23-90	Ni-P	250	8.90	2.000	1.000	0.063	27.84	18.8014	18.1989	0.6025	4.00	2.39E-01	
140 deg. F Mechanical Agitation pH as a variable - First test pH-9.99														
NiPlex100	3-14-90	Ni-S	452	8.90	2.000	1.000	0.063	27.84	22.6773	21.9205	0.7568	1.00	1.20E+00	1.41E+00
NiPlex100	3-14-90	Ni-S	499	8.90	2.000	1.000	0.063	27.84	21.5052	20.4908	1.0144	1.00	1.61E+00	
NiPlex100	3-14-90	Ni-P	098	8.90	2.000	1.000	0.063	27.84	18.7956	18.1947	0.6009	1.00	9.55E-01	9.43E-01
NiPlex100	3-14-90	Ni-P	127	8.90	2.000	1.000	0.063	27.84	19.0730	18.4870	0.5860	1.00	9.31E-01	
NiPlex100	3-14-90	Ni-S	520	8.90	2.000	1.000	0.063	27.84	21.6605	20.2370	1.4235	2.00	1.13E+00	1.12E+00
NiPlex100	3-14-90	Ni-S	535	8.90	2.000	1.000	0.063	27.84	21.6897	20.2957	1.3940	2.00	1.11E+00	
NiPlex100	3-14-90	Ni-P	131	8.90	2.000	1.000	0.063	27.84	18.8491	17.9073	0.9418	2.00	7.48E-01	7.16E-01
NiPlex100	3-14-90	Ni-P	191	8.90	2.000	1.000	0.063	27.84	18.4689	17.6080	0.8609	2.00	6.84E-01	
NiPlex100	3-14-90	Ni-S	570	8.90	2.000	1.000	0.063	27.84	21.9481	19.4408	2.5073	4.00	9.96E-01	9.54E-01
NiPlex100	3-14-90	Ni-S	598	8.90	2.000	1.000	0.063	27.84	21.8205	19.5225	2.2980	4.00	9.13E-01	
NiPlex100	3-14-90	Ni-P	196	8.90	2.000	1.000	0.063	27.84	19.0324	17.0543	1.9781	4.00	7.86E-01	7.39E-01
NiPlex100	3-14-90	Ni-P	245	8.90	2.000	1.000	0.063	27.84	18.8760	17.1354	1.7406	4.00	6.91E-01	

Stripper	Test Date	Coupon Material	Coupon #	Density (g/cm3)	Unmasked Dimensions in inches length	width	thick	Surface Area (cm2)	Initial Mass (grams)	Final Mass (grams)	Change Mass (grams)	Total Time (hours)	Stripping Rate (mil/hr)	Average S.R. (mil/hr)
150 deg. F	Mechanical Agitation	pH as a variable – Second Test	pH-10.5											
NiPlex100	3-15-90	Ni-S	340	8.90	2.000	1.000	0.063	27.84	22.9287	22.3589	0.5698	1.00	9.05E-01	1.06E+00
NiPlex100	3-15-90	Ni-S	420	8.90	2.000	1.000	0.063	27.84	21.4178	20.6496	0.7682	1.00	1.22E+00	
NiPlex100	3-15-90	Ni-P	008	8.90	2.000	1.000	0.063	27.84	18.9719	18.5534	0.4185	1.00	6.65E-01	6.65E-01
NiPlex100	3-15-90	Ni-P	161	8.90	2.000	1.000	0.063	27.84	18.8733	18.4547	0.4186	1.00	6.65E-01	
NiPlex100	3-15-90	Ni-S	429	8.90	2.000	1.000	0.063	27.84	23.1207	22.0034	1.1173	2.00	8.88E-01	1.06E+00
NiPlex100	3-15-90	Ni-S	431	8.90	2.000	1.000	0.063	27.84	22.6213	21.0661	1.5552	2.00	1.24E+00	
NiPlex100	3-15-90	Ni-P	183	8.90	2.000	1.000	0.063	27.84	18.9592	18.0073	0.9519	2.00	7.56E-01	7.96E-01
NiPlex100	3-15-90	Ni-P	229	8.90	2.000	1.000	0.063	27.84	18.8842	17.8320	1.0522	2.00	8.36E-01	
NiPlex100	3-15-90	Ni-S	438	8.90	2.000	1.000	0.063	27.84	23.1405	20.9232	2.2173	4.00	8.81E-01	9.35E-01
NiPlex100	3-15-90	Ni-S	592	8.90	2.000	1.000	0.063	27.84	22.9881	20.4958	2.4923	4.00	9.90E-01	
NiPlex100	3-15-90	Ni-P	231	8.90	2.000	1.000	0.063	27.84	18.8099	17.1381	1.6718	4.00	6.64E-01	6.85E-01
NiPlex100	3-15-90	Ni-P	233	8.90	2.000	1.000	0.063	27.84	18.8817	17.1024	1.7793	4.00	7.07E-01	
140 deg. F	pH-11.11													
NiPlex100	6-26-90	Ni-S	305	8.90	2.045	1.042	0.080	30.14	22.4196	21.9107	0.5089	1.00	7.47E-01	7.18E-01
NiPlex100	6-26-90	Ni-S	390	8.90	2.060	1.040	0.082	30.37	22.9569	22.4836	0.4733	1.00	6.89E-01	
NiPlex100	6-26-90	Ni-P	006	8.90	2.018	1.015	0.076	28.91	19.0724	18.7319	0.3405	1.00	5.21E-01	4.94E-01
NiPlex100	6-26-90	Ni-P	184	8.90	2.020	1.012	0.076	28.85	18.7649	18.4604	0.3045	1.00	4.67E-01	
NiPlex100	6-26-90	Ni-S	400	8.90	2.040	1.039	0.078	29.93	21.7525	20.9972	0.7553	2.00	5.58E-01	5.86E-01
NiPlex100	6-26-90	Ni-S	418	8.90	2.045	1.045	0.081	30.26	22.2713	21.4318	0.8395	2.00	6.14E-01	
NiPlex100	6-26-90	Ni-P	260	8.90	2.030	1.015	0.076	29.07	18.9059	18.3644	0.5415	2.00	4.12E-01	3.98E-01
NiPlex100	6-26-90	Ni-P	266	8.90	2.017	1.012	0.075	28.78	18.6396	18.1406	0.4990	2.00	3.83E-01	
NiPlex100	6-26-90	Ni-S	577	8.90	2.050	1.040	0.082	30.23	21.8970	20.3935	1.5035	4.00	5.50E-01	5.37E-01
NiPlex100	6-26-90	Ni-S	589	8.90	2.055	1.047	0.080	30.42	22.3673	20.9271	1.4402	4.00	5.24E-01	
NiPlex100	6-26-90	Ni-P	275	8.90	2.025	1.018	0.076	29.08	19.0007	17.8473	1.1534	4.00	4.39E-01	4.19E-01
NiPlex100	6-26-90	Ni-P	279	8.90	2.026	1.012	0.076	28.94	18.8338	17.7878	1.0460	4.00	4.00E-01	
140 deg. F	pH-11.11													
NiPlex100	6-26-90	410	128	7.70	2.018	1.008	0.061	28.23	14.3761	14.3759	0.0002	24.00	1.51E-05	8.97E-05
NiPlex100	6-26-90	410	129	7.70	2.014	1.022	0.060	28.51	14.5574	14.5552	0.0022	24.00	1.64E-04	
NiPlex100	6-26-90	C4340	068	7.84	2.009	0.998	0.062	27.88	14.8790	14.8777	0.0013	24.00	9.76E-05	3.91E-06
NiPlex100	6-26-90	C4340	069	7.84	2.012	0.999	0.063	27.98	15.1568	15.1580	-0.0012	24.00	-8.97E-05	
NiPlex100	6-26-90	D6AC	066	8.20	2.035	1.008	0.066	28.63	16.2591	16.2572	0.0019	24.00	1.33E-04	2.15E-04
NiPlex100	6-26-90	D6AC	067	8.20	2.010	1.010	0.084	28.92	20.2307	20.2264	0.0043	24.00	2.97E-04	
NiPlex100	6-26-90	321	111	7.92	2.017	1.005	0.062	28.17	15.2176	15.2173	0.0003	24.00	2.21E-05	1.47E-05
NiPlex100	6-26-90	321	112	7.92	2.014	1.005	0.062	28.13	15.0007	15.0006	0.0001	24.00	7.36E-06	
NiPlex100	6-26-90	I-718	64	8.60	2.015	1.002	0.063	28.10	16.0789	16.0786	0.0003	24.00	2.04E-05	1.02E-05
NiPlex100	6-26-90	I-718	65	8.60	2.018	1.001	0.064	28.14	16.2051	16.2051	0.0000	24.00	0.00E+00	
NiPlex100	6-26-90	HA188	14	9.70	2.012	1.000	0.060	27.91	16.9427	16.9426	0.0001	24.00	6.06E-06	2.11E-05
NiPlex100	6-26-90	HA188	15	9.70	2.024	1.002	0.060	28.12	16.8057	16.8051	0.0006	24.00	3.61E-05	
NiPlex100	6-26-90	316	6	8.00	2.014	1.020	0.057	28.36	14.4760	14.4760	0.0000	24.00	0.00E+00	0.00E+00
NiPlex100	6-26-90	316	7	8.00	2.017	1.019	0.058	28.41	14.6071	14.6071	0.0000	24.00	0.00E+00	

APPENDIX G

STRIPPING RATE DATA FOR THE FIELD TESTING OF

ENTHONE'S ENSTRIP N-190

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Stripper	Test Date	Coupon Material	Coupon #	Density (g/cm3)	Unmasked Dimensions in inches length	width	thick	Surface Area (cm2)	Initial Mass (grams)	Final Mass (grams)	Change Mass (grams)	Total Time (hours)	Stripping Rate (mil/hr)	Average S.R. (mil/hr)
120 deg. F 2 Liters pH−12.28 Magnetic Stirring														
N−190	9−18−90	HA 188	140	9.70	1.375	1.006	0.061	19.33	17.3067	17.3069	−0.0002	24.00	−1.75E−05	−8.75E−06
N−190	9−18−90	HA 188	141	9.70	1.375	0.998	0.060	19.16	17.0342	17.0342	0.0000	24.00	0.00E+00	
N−190	9−18−90	410	37	7.70	1.406	1.025	0.060	20.08	14.6372	14.6372	0.0000	24.00	0.00E+00	−5.33E−06
N−190	9−18−90	410	81	7.70	1.406	1.020	0.060	19.99	14.4549	14.4550	−0.0001	24.00	−1.07E−05	
N−190	9−18−90	316	79	8.00	1.375	1.005	0.058	19.24	14.0428	14.0426	0.0002	24.00	2.13E−05	1.07E−05
N−190	9−18−90	316	80	8.00	1.344	1.004	0.058	18.79	14.1383	14.1383	0.0000	24.00	0.00E+00	
N−190	9−18−90	C4340	93	7.84	1.375	1.000	0.061	19.22	14.6780	14.6776	0.0004	24.00	4.36E−05	4.26E−05
N−190	9−18−90	C4340	94	7.84	1.438	0.999	0.062	20.09	15.0598	15.0594	0.0004	24.00	4.17E−05	
N−190	9−18−90	17−4PH	49	7.80	1.375	1.003	0.063	19.32	14.7642	14.7644	−0.0002	24.00	−2.18E−05	−2.22E−05
N−190	9−18−90	17−4PH	52	7.80	1.313	1.016	0.062	18.67	14.8830	14.8832	−0.0002	24.00	−2.25E−05	
N−190	9−18−90	I−718	53	8.60	1.343	1.003	0.062	18.86	16.0070	16.0071	−0.0001	24.00	−1.01E−05	−5.06E−06
N−190	9−18−90	I−718	87	8.60	1.375	1.021	0.063	19.65	16.5622	16.5622	0.0000	24.00	0.00E+00	
N−190	9−18−90	D6AC	149	8.20	1.343	1.015	0.080	19.50	19.4360	19.4352	0.0008	24.00	8.21E−05	8.42E−05
N−190	9−18−90	D6AC	145	8.20	1.438	1.025	0.074	20.88	18.8699	18.8690	0.0009	24.00	8.62E−05	
N−190	9−18−90	Ni−S	437	8.90	1.375	1.047	0.087	20.71	23.6961	22.1009	1.5952	2.50	1.36E+00	1.38E+00
N−190	9−18−90	Ni−S	451	8.90	1.478	1.041	0.086	22.07	23.1398	21.3917	1.7481	2.50	1.40E+00	
N−190	9−18−90	Ni−P	13	8.90	1.478	1.023	0.069	21.28	17.1197	16.9619	0.1578	2.50	1.31E−01	1.70E−01
N−190	9−18−90	Ni−P	14	8.90	1.469	1.020	0.071	21.15	17.4282	17.1775	0.2507	2.50	2.10E−01	
N−190	9−18−90	Ni−S	480	8.90	1.375	1.042	0.089	20.66	22.1410	19.6464	2.4946	4.00	1.34E+00	1.28E+00
N−190	9−18−90	Ni−S	551	8.90	1.375	1.053	0.088	20.84	23.8007	21.5008	2.2999	4.00	1.22E+00	
N−190	9−18−90	Ni−P	5	8.90	1.438	1.021	0.070	20.70	17.4362	17.1624	0.2738	4.00	1.46E−01	1.41E−01
N−190	9−18−90	Ni−P	45	8.90	1.439	1.021	0.070	20.72	17.1667	16.9124	0.2543	4.00	1.36E−01	
120 deg F 2 Liters pH−11.78 Magnetic Stirring														
N−190	9−11−90	Ni−S	27	8.90	1.375	1.036	0.075	20.21	19.5188	18.3782	1.1406	2.00	1.25E+00	1.29E+00
N−190	9−11−90	Ni−S	28	8.90	1.410	1.034	0.072	20.60	18.3687	17.1314	1.2373	2.00	1.33E+00	
N−190	9−11−90	Ni−P	1	8.90	1.343	1.023	0.070	19.40	17.2014	17.0451	0.1563	2.00	1.78E−01	1.78E−01
N−190	9−11−90	Ni−P	2	8.90	1.343	1.020	0.070	19.35	17.0238	16.8687	0.1551	2.00	1.77E−01	
N−190	9−11−90	Ni−S	37	8.90	1.410	1.034	0.073	20.63	19.1213	16.8641	2.2572	4.00	1.21E+00	1.24E+00
N−190	9−11−90	Ni−S	41	8.90	1.438	1.040	0.076	21.22	20.0704	17.6533	2.4171	4.00	1.26E+00	
N−190	9−11−90	Ni−P	3	8.90	1.438	1.020	0.071	20.71	17.4552	17.0975	0.3577	4.00	1.91E−01	1.62E−01
N−190	9−11−90	Ni−P	4	8.90	1.469	1.023	0.069	21.15	17.0301	16.7749	0.2552	4.00	1.33E−01	
120 deg. F 2 Liters pH−11.28 Magnetic Stirring														
N−190	9−10−90	Ni−S	42	8.90	1.410	1.036	0.075	20.71	19.4514	18.7709	0.6805	2.00	7.27E−01	5.94E−01
N−190	9−10−90	Ni−S	44	8.90	1.375	1.033	0.075	20.16	19.3090	18.8880	0.4210	2.00	4.62E−01	
N−190	9−10−90	Ni−P	12	8.90	1.343	1.025	0.070	19.44	17.2350	17.1224	0.1126	2.00	1.28E−01	1.30E−01
N−190	9−10−90	Ni−P	29	8.90	1.375	1.026	0.070	19.91	17.2584	17.1389	0.1195	2.00	1.33E−01	
N−190	9−10−90	Ni−S	48	8.90	1.343	1.032	0.075	19.68	19.4963	18.3296	1.1667	4.00	6.56E−01	5.58E−01
N−190	9−10−90	Ni−S	50	8.90	1.313	1.029	0.073	19.15	18.8886	18.0895	0.7991	4.00	4.61E−01	
N−190	9−10−90	Ni−P	30	8.90	1.313	1.024	0.070	19.00	17.3933	17.1050	0.2883	4.00	1.68E−01	1.65E−01
N−190	9−10−90	Ni−P	39	8.90	1.375	1.024	0.070	19.87	17.1859	16.8958	0.2901	4.00	1.61E−01	

Stripper	Test Date	Coupon Material	Coupon #	Density (g/cm3)	Unmasked Dimensions in inches length	width	thick	Surface Area (cm2)	Initial Mass (grams)	Final Mass (grams)	Change Mass (grams)	Total Time (hours)	Stripping Rate (mil/hr)	Average S.R. (mil/hr)
120 deg. F	2 Liters pH-10.78 Magnetic Agitation													
N-190	9-7-90	Ni-S	29	8.90	1.280	1.036	0.078	18.92	19.9035	18.4686	1.4349	2.00	1.68E+00	1.60E+00
N-190	9-7-90	Ni-S	30	8.90	1.280	1.036	0.075	18.85	19.8134	18.5201	1.2933	2.00	1.52E+00	
N-190	9-7-90	Ni-P	9	8.90	1.310	1.018	0.069	18.83	17.0634	16.9481	0.1153	2.00	1.35E-01	1.35E-01
N-190	9-7-90	Ni-P	10	8.90	1.310	1.026	0.070	18.99	17.3230	17.2079	0.1151	2.00	1.34E-01	
N-190	9-7-90	Ni-S	31	8.90	1.343	1.034	0.074	19.69	19.2121	17.0601	2.1520	4.00	1.21E+00	1.20E+00
N-190	9-7-90	Ni-S	35	8.90	1.375	1.044	0.078	20.43	20.8069	18.6196	2.1873	4.00	1.18E+00	
N-190	9-7-90	Ni-P	27	8.90	1.343	1.023	0.070	19.40	17.1537	16.9024	0.2513	4.00	1.43E-01	1.40E-01
N-190	9-7-90	Ni-P	36	8.90	1.310	1.024	0.070	18.95	17.1708	16.9374	0.2334	4.00	1.36E-01	
120 deg. F	15 gal pH 10.88 Mechanical Agitation													
N-190	8-8-90	Ni-S	01	8.90	1.438	1.042	0.076	21.25	19.8668	19.0380	0.8288	1.00	1.73E+00	1.72E+00
N-190	8-8-90	Ni-S	02	8.90	1.375	1.030	0.075	20.10	19.2509	18.4755	0.7754	1.00	1.71E+00	
N-190	8-8-90	Ni-P	10	8.90	1.438	1.016	0.075	20.73	19.0807	18.9782	0.1025	1.00	2.19E-01	1.89E-01
N-190	8-8-90	Ni-P	12	8.90	1.344	1.014	0.076	19.40	18.8912	18.8217	0.0695	1.00	1.59E-01	
N-190	8-8-90	Ni-S	05	8.90	1.375	1.032	0.076	20.16	18.7468	17.4057	1.3411	2.00	1.47E+00	1.42E+00
N-190	8-8-90	Ni-S	06	8.90	1.344	1.040	0.082	20.00	22.5334	21.2904	1.2430	2.00	1.37E+00	
N-190	8-8-90	Ni-P	30	8.90	1.406	1.012	0.074	20.19	18.6856	18.5525	0.1331	2.00	1.46E-01	1.55E-01
N-190	8-8-90	Ni-P	36	8.90	1.438	1.012	0.076	20.68	19.0377	18.8845	0.1532	2.00	1.64E-01	
N-190	8-8-90	Ni-S	07	8.90	1.438	1.032	0.074	21.01	19.4401	17.5162	1.9239	4.00	1.01E+00	1.02E+00
N-190	8-8-90	Ni-S	08	8.90	1.406	1.032	0.076	20.61	19.5753	17.6507	1.9246	4.00	1.03E+00	
N-190	8-8-90	Ni-P	38	8.90	1.313	1.012	0.076	18.92	18.9158	18.6649	0.2509	4.00	1.47E-01	1.62E-01
N-190	8-8-90	Ni-P	46	8.90	1.219	1.012	0.076	17.61	19.0317	18.7492	0.2825	4.00	1.77E-01	
N-190	8-8-90	410	87	7.70	1.469	1.010	0.059	20.64	14.2260	14.2260	0.0000	24.00	0.00E+00	0.00E+00
N-190	8-8-90	410	89	7.70	1.500	1.012	0.060	21.14	14.5452	14.5452	0.0000	24.00	0.00E+00	
N-190	8-8-90	C4340	22	7.84	1.500	0.995	0.061	20.83	14.3823	14.3820	0.0003	24.00	3.01E-05	2.02E-05
N-190	8-8-90	C4340	29	7.84	1.469	0.997	0.062	20.47	14.7659	14.7658	0.0001	24.00	1.02E-05	
N-190	8-8-90	D6AC	127	8.20	1.500	1.017	0.082	21.81	20.0995	20.0997	-0.0002	24.00	-1.83E-05	-1.38E-05
N-190	8-8-90	D6AC	128	8.20	1.500	1.010	0.081	21.64	20.1860	20.1861	-0.0001	24.00	-9.24E-06	
N-190	8-8-90	17-4PH	28	7.80	1.469	1.008	0.063	20.71	15.2093	15.2094	-0.0001	24.00	-1.02E-05	-2.04E-05
N-190	8-8-90	17-4PH	30	7.80	1.469	1.004	0.063	20.63	14.5824	14.5827	-0.0003	24.00	-3.06E-05	
N-190	8-8-90	I-718	21	8.60	1.500	1.002	0.063	21.02	16.0110	16.0110	0.0000	24.00	0.00E+00	-9.07E-06
N-190	8-8-90	I-718	28	8.60	1.500	1.003	0.063	21.04	16.1159	16.1161	-0.0002	24.00	-1.81E-05	
N-190	8-8-90	HA188	106	9.70	1.500	1.003	0.060	20.96	17.1007	17.1009	-0.0002	24.00	-1.61E-05	-2.04E-05
N-190	8-8-90	HA188	107	9.70	1.469	1.003	0.059	20.51	16.8831	16.8834	-0.0003	24.00	-2.47E-05	
N-190	8-8-90	316	15	8.00	1.500	1.004	0.057	20.90	14.1608	14.1608	0.0000	24.00	0.00E+00	4.90E-06
N-190	8-8-90	316	16	8.00	1.500	1.004	0.057	20.90	14.2106	14.2105	0.0001	24.00	9.81E-06	
130 deg. F	15 gal Mechanical Agitation 2nd Test													
N-190	8-10-90	Ni-S	10	8.90	1.313	1.036	0.075	19.32	19.5663	18.5417	1.0246	1.00	2.35E+00	2.30E+00
N-190	8-10-90	Ni-S	12	8.90	1.375	1.033	0.076	20.18	19.3631	18.3314	1.0317	1.00	2.26E+00	
N-190	8-10-90	Ni-P	48	8.90	1.375	1.013	0.076	19.82	19.0933	18.9386	0.1547	1.00	3.45E-01	3.48E-01
N-190	8-10-90	Ni-P	96	8.90	1.313	1.012	0.076	18.92	19.0986	18.9488	0.1498	1.00	3.50E-01	
N-190	8-10-90	Ni-S	14	8.90	1.406	1.028	0.074	20.49	18.7841	17.1287	1.6554	2.00	1.79E+00	1.86E+00
N-190	8-10-90	Ni-S	15	8.90	1.344	1.036	0.075	19.76	20.4011	18.6740	1.7271	2.00	1.93E+00	
N-190	8-10-90	Ni-P	108	8.90	1.406	1.013	0.076	20.26	19.0100	18.7864	0.2236	2.00	2.44E-01	2.55E-01

Stripper	Test Date	Coupon Material	Coupon #	Density (g/cm3)	Unmasked Dimensions in inches length	width	thick	Surface Area (cm2)	Initial Mass (grams)	Final Mass (grams)	Change Mass (grams)	Total Time (hours)	Stripping Rate (mil/hr)	Average S.R. (mil/hr)
N-190	8-10-90	Ni-P	136	8.90	1.406	1.014	0.076	20.27	18.9176	18.6733	0.2443	2.00	2.67E-01	
N-190	8-10-90	Ni-S	16	8.90	1.375	1.033	0.075	20.16	19.3623	17.0463	2.3160	4.00	1.27E+00	1.25E+00
N-190	8-10-90	Ni-S	17	8.90	1.375	1.040	0.078	20.36	21.8000	19.5244	2.2756	4.00	1.24E+00	
N-190	8-10-90	Ni-P	145	8.90	1.344	1.010	0.075	19.30	18.6205	18.3770	0.2435	4.00	1.40E-01	1.47E-01
N-190	8-10-90	Ni-P	146	8.90	1.375	1.012	0.076	19.80	19.0082	18.7306	0.2776	4.00	1.55E-01	
150 deg. F	15 gal	pH 10.9	Mechanical Agitation											
N-190	8-8-90	410	87	7.70	1.469	1.010	0.059	20.64	14.2260	14.2255	0.0005	24.00	5.16E-05	5.21E-05
N-190	8-8-90	410	89	7.70	1.438	1.012	0.060	20.28	14.5452	14.5447	0.0005	24.00	5.25E-05	
N-190	8-8-90	C4340	22	7.84	1.406	0.995	0.061	19.55	14.3820	14.3816	0.0004	24.00	4.28E-05	5.27E-05
N-190	8-8-90	C4340	29	7.84	1.438	0.997	0.062	20.04	14.7658	14.7652	0.0006	24.00	6.26E-05	
N-190	8-8-90	D6AC	127	8.20	1.438	1.017	0.082	20.92	20.0997	20.0987	0.0010	24.00	9.56E-05	1.03E-04
N-190	8-8-90	D6AC	128	8.20	1.375	1.010	0.081	19.88	20.1861	20.1850	0.0011	24.00	1.11E-04	
N-190	8-8-90	17-4PH	28	7.80	1.438	1.008	0.063	20.27	15.2094	15.2090	0.0004	24.00	4.15E-05	4.62E-05
N-190	8-8-90	17-4PH	30	7.80	1.469	1.004	0.063	20.63	14.5827	14.5822	0.0005	24.00	5.10E-05	
N-190	8-8-90	I-718	21	8.60	1.438	1.002	0.063	20.16	16.0110	16.0108	0.0002	24.00	1.89E-05	3.31E-05
N-190	8-8-90	I-718	28	8.60	1.438	1.003	0.063	20.18	16.1161	16.1156	0.0005	24.00	4.73E-05	
N-190	8-8-90	HA 188	106	9.70	1.406	1.002	0.060	19.66	17.1009	17.1001	0.0008	24.00	6.88E-05	5.91E-05
N-190	8-8-90	HA 188	107	9.70	1.469	1.003	0.059	20.51	16.8834	16.8828	0.0006	24.00	4.95E-05	
N-190	8-8-90	316	15	8.00	1.469	1.004	0.057	20.48	14.1608	14.1605	0.0003	24.00	3.00E-05	5.15E-05
N-190	8-8-90	316	28	8.00	1.406	1.006	0.058	19.68	14.1358	14.1351	0.0007	24.00	7.29E-05	
N-190	8-14-90	Ni-S	19	8.90	1.400	1.031	0.075	20.48	19.4369	18.5314	0.9055	1.00	1.96E+00	1.95E+00
N-190	8-14-90	Ni-S	21	8.90	1.344	1.032	0.074	19.67	18.8163	17.9503	0.8660	1.00	1.95E+00	
N-190	8-14-90	Ni-P	167	8.90	1.375	1.011	0.075	19.76	18.9526	18.8079	0.1447	1.00	3.24E-01	3.08E-01
N-190	8-14-90	Ni-P	182	8.90	1.406	1.010	0.075	20.17	18.9433	18.8097	0.1336	1.00	2.93E-01	
N-190	8-14-90	Ni-S	23	8.90	1.438	1.029	0.074	20.96	18.7723	17.4004	1.3719	2.00	1.45E+00	1.63E+00
N-190	8-14-90	Ni-S	24	8.90	1.438	1.045	0.075	21.29	19.3782	17.6426	1.7356	2.00	1.80E+00	
N-190	8-14-90	Ni-P	187	8.90	1.406	1.020	0.075	20.36	18.8077	18.4768	0.3309	2.00	3.59E-01	3.49E-01
N-190	8-14-90	Ni-P	193	8.90	1.406	1.011	0.075	20.19	18.6626	18.3538	0.3088	2.00	3.38E-01	
N-190	8-14-90	Ni-S	25	8.90	1.406	1.030	0.075	20.55	19.4664	17.6552	1.8112	4.00	9.75E-01	1.06E+00
N-190	8-14-90	Ni-S	26	8.90	1.406	1.028	0.075	20.51	19.5335	17.4131	2.1204	4.00	1.14E+00	
N-190	8-14-90	Ni-P	201	8.90	1.406	1.012	0.075	20.21	18.9071	17.9749	0.9322	4.00	5.10E-01	2.82E-01
N-190	8-14-90	Ni-P	204	8.90	1.406	1.010	0.074	20.15	18.8106	17.8751	0.0998	4.00	5.48E-02	
140 deg. F	10 gal	pH 10.88	Mechanical Agitation	Nickel loaded 0.5 oz/gal										
N-190	8-17-90	Ni-S	3	8.90	1.531	1.046	0.079	22.76	21.4631	20.3832	1.0799	1.00	2.10E+00	2.10E+00
N-190	8-17-90	Ni-S	4	8.90	1.531	1.033	0.074	22.36	18.4065	17.3414	1.0651	1.00	2.11E+00	
N-190	8-17-90	Ni-P	21	8.90	1.563	1.022	0.070	22.48	17.1100	16.9901	0.1199	1.00	2.36E-01	1.87E-01
N-190	8-17-90	Ni-P	26	8.90	1.563	1.021	0.071	22.49	17.7565	17.6858	0.0707	1.00	1.39E-01	
N-190	8-17-90	Ni-S	20	8.90	1.594	1.040	0.077	23.49	20.5086	19.3997	1.1089	2.00	1.04E+00	1.53E+00
N-190	8-17-90	Ni-S	22	8.90	1.563	1.047	0.079	23.24	21.2777	19.1532	2.1245	2.00	2.02E+00	
N-190	8-17-90	Ni-P	32	8.90	1.563	1.021	0.069	22.44	17.0290	16.9307	0.0983	2.00	9.69E-02	8.84E-02
N-190	8-17-90	Ni-P	33	8.90	1.563	1.019	0.070	22.42	17.1827	17.1017	0.0810	2.00	7.99E-02	
N-190	8-17-90	Ni-S	33	8.90	1.594	1.040	0.075	23.44	21.2050	18.6573	2.5477	4.00	1.20E+00	1.00E+00
N-190	8-17-90	Ni-S	34	8.90	1.563	1.031	0.074	22.78	18.9160	17.2650	1.6510	4.00	8.02E-01	
N-190	8-17-90	Ni-P	47	8.90	1.563	1.023	0.070	22.51	17.2991	17.1821	0.1170	4.00	5.75E-02	4.95E-02
N-190	8-17-90	Ni-P	49	8.90	1.563	1.022	0.070	22.48	17.2161	17.0976	0.0845	4.00	4.16E-02	

Stripper	Test Date	Coupon Material	Coupon #	Density (g/cm3)	Unmasked Dimensions in inches length	width	thick	Surface Area (cm2)	Initial Mass (grams)	Final Mass (grams)	Change Mass (grams)	Total Time (hours)	Stripping Rate (mil/hr)	Average S.R. (mil/hr)
140 deg. F	10 gal pH 10.88	Mechanical Agitation		Nickel loaded 1.0 oz/gal										
N−190	8−17−90	Ni−S	49	8.90	1.438	1.051	0.082	21.58	20.8443	20.2425	0.6018	1.00	1.23E+00	8.79E−01
N−190	8−17−90	Ni−S	46	8.90	1.344	1.031	0.077	19.73	19.3456	19.1117	0.2339	1.00	5.24E−01	
N−190	8−17−90	Ni−P	48	8.90	1.313	1.028	0.073	19.14	17.6915	17.4147	0.2768	1.00	6.40E−01	4.60E−01
N−190	8−17−90	Ni−P	43	8.90	1.344	1.022	0.070	19.40	17.1080	16.9852	0.1228	1.00	2.80E−01	
N−190	8−17−90	Ni−S	40	8.90	1.344	1.043	0.084	20.11	21.8285	21.5544	0.2741	2.00	3.01E−01	3.13E−01
N−190	8−17−90	Ni−S	39	8.90	1.250	1.038	0.077	18.50	19.6901	19.4193	0.2708	2.00	3.24E−01	
N−190	8−17−90	Ni−P	40	8.90	1.313	1.026	0.070	19.03	16.7333	16.4566	0.2767	2.00	3.22E−01	2.97E−01
N−190	8−17−90	Ni−P	35	8.90	1.344	1.025	0.071	19.48	17.2365	16.9974	0.2391	2.00	2.72E−01	
N−190	8−17−90	Ni−S	32	8.90	1.313	1.035	0.077	19.35	19.0644	18.6320	0.4324	4.00	2.47E−01	2.20E−01
N−190	8−17−90	Ni−S	9	8.90	1.313	1.027	0.078	19.24	19.1753	18.8408	0.3345	4.00	1.92E−01	
N−190	8−17−90	Ni−P	22	8.90	1.313	1.019	0.070	18.91	16.9633	16.4999	0.4634	4.00	2.71E−01	2.77E−01
N−190	8−17−90	Ni−P	15	8.90	1.313	1.023	0.071	19.00	17.0810	16.5960	0.4850	4.00	2.82E−01	
140 deg. F	10 gal pH−10.9	Mechanical Agitation		Nickel loaded approx. 1.5 oz/gal										
N−190	8−23−90	17−4PH	12	7.80	1.438	1.009	0.064	20.33	14.9115	14.9112	0.0003	24.00	3.10E−05	2.59E−05
N−190	8−23−90	17−4PH	36	7.80	1.438	1.004	0.063	20.21	14.5544	14.5542	0.0002	24.00	2.08E−05	
N−190	8−23−90	316	76	8.00	1.500	1.000	0.058	20.85	13.6093	13.6088	0.0005	24.00	4.92E−05	3.92E−05
N−190	8−23−90	316	77	8.00	1.500	1.006	0.060	21.02	14.2042	14.2039	0.0003	24.00	2.93E−05	
N−190	8−23−90	410	73	7.70	1.438	0.998	0.059	19.99	14.2399	14.2395	0.0004	24.00	4.26E−05	1.62E−05
N−190	8−23−90	410	74	7.70	1.438	1.038	0.059	20.75	14.2742	14.2743	−0.0001	24.00	−1.03E−05	
N−190	8−23−90	C4340	14	7.84	1.438	1.003	0.062	20.16	14.9660	14.9657	0.0003	24.00	3.11E−05	9.12E−05
N−190	8−23−90	C4340	15	7.84	1.280	1.003	0.062	17.99	14.9096	14.9083	0.0013	24.00	1.51E−04	
N−190	8−23−90	D6AC	106	8.20	1.440	1.014	0.075	20.72	18.0608	18.0598	0.0010	24.00	9.65E−05	7.12E−05
N−190	8−23−90	D6AC	133	8.20	1.500	1.023	0.076	21.77	18.7111	18.7106	0.0005	24.00	4.59E−05	
N−190	8−23−90	HA188	133	9.70	1.438	1.007	0.061	20.21	17.4425	17.4426	−0.0001	24.00	−8.37E−06	−4.18E−06
N−190	8−23−90	HA188	134	9.70	1.438	1.007	0.060	20.19	16.9958	16.9958	0.0000	24.00	0.00E+00	
N−190	8−23−90	I−718	31	8.60	1.438	1.002	0.064	20.19	16.1107	16.1099	0.0008	24.00	7.56E−05	6.24E−05
N−190	8−23−90	I−718	32	8.60	1.380	1.003	0.063	19.39	16.1445	16.1440	0.0005	24.00	4.92E−05	
N−190	8−23−90	Ni−S	47	8.90	1.310	1.039	0.079	19.43	19.5091	19.0229	0.4862	1.00	1.11E+00	1.23E+00
N−190	8−23−90	Ni−S	45	8.90	1.250	1.033	0.076	18.39	18.8862	18.3215	0.5647	1.00	1.36E+00	
N−190	8−23−90	Ni−P	44	8.90	1.310	1.023	0.070	18.94	16.9222	16.8423	0.0799	1.00	1.87E−01	2.18E−01
N−190	8−23−90	Ni−P	25	8.90	1.310	1.025	0.070	18.97	17.0572	16.9505	0.1067	1.00	2.49E−01	
N−190	8−23−90	Ni−S	43	8.90	1.310	1.034	0.077	19.29	19.1719	18.1427	1.0292	2.00	1.18E+00	1.31E+00
N−190	8−23−90	Ni−S	18	8.90	1.250	1.031	0.079	18.43	19.0929	17.8945	1.1984	2.00	1.44E+00	
N−190	8−23−90	Ni−P	23	8.90	1.250	1.024	0.070	18.11	17.2050	17.0188	0.1862	2.00	2.27E−01	2.40E−01
N−190	8−23−90	Ni−P	20	8.90	1.310	1.019	0.071	18.89	17.1807	16.9648	0.2159	2.00	2.53E−01	
N−190	8−23−90	Ni−S	13	8.90	1.250	1.041	0.078	18.57	19.6612	18.4699	1.1913	4.00	7.09E−01	6.30E−01
N−190	8−23−90	Ni−S	11	8.90	1.310	1.049	0.080	19.63	20.3914	19.4152	0.9762	4.00	5.50E−01	
N−190	8−23−90	Ni−P	19	8.90	1.343	1.019	0.070	19.33	17.2267	16.7122	0.5145	4.00	2.94E−01	3.00E−01
N−190	8−23−90	Ni−P	16	8.90	1.310	1.026	0.071	19.01	17.4094	16.8855	0.5239	4.00	3.05E−01	

APPENDIX H

STRIPPING RATE DATA FOR THE FIELD TESTING OF KAFB'S
ELECTROLYTIC CYANIDE PROCESS (C-101)

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Stripper	Test Date	Coupon Material	Coupon #	Density (g/cm3)	Unwaxed Dimensions --------in inches-------- length	width	thick	Surface Area (cm2)	Initial Mass (grams)	Final Mass (grams)	Change Mass (grams)	Total Time (hours)	Stripping Rate (mil/hr)	Average S.R. (mil/hr)
C101	6-01-90	17-4 PH	-	7.80	1.500	1.000	0.063	20.97	14.4454	14.4723	-0.0269	1.00	-6.48E-02	-5.80E-02
C101	6-01-90	17-4 PH	-	7.80	1.500	1.000	0.063	20.98	15.2180	15.2393	-0.0213	1.00	-5.12E-02	
C101	6-01-90	316	-	8.03	1.500	1.000	0.063	20.98	14.0339	14.0159	0.0180	8.00	5.26E-03	5.23E-03
C101	6-01-90	316	-	8.03	1.500	1.000	0.063	20.98	13.9340	13.9162	0.0178	8.00	5.20E-03	
C101	6-01-90	410	137	7.70	1.500	1.000	0.063	20.98	13.9461	13.9391	0.0070	1.00	1.71E-02	4.87E-03
C101	6-01-90	410	136	7.70	1.500	1.000	0.063	20.98	14.1535	14.1565	-0.0030	1.00	-7.31E-03	
C101	6-01-90	Ag	001	10.50	1.500	1.000	0.125	22.58	39.3407	38.0282	1.3125	0.25	8.72E+00	8.93E+00
C101	6-01-90	Ag	002	10.50	1.500	1.000	0.125	22.58	41.8921	40.5167	1.3754	0.25	9.14E+00	
C101	6-01-90	C4340	045	7.84	1.500	1.000	0.063	20.98	14.4347	14.4351	-0.0004	1.00	-9.57E-04	-4.91E-03
C101	6-01-90	C4340	044	7.84	1.500	1.000	0.063	20.98	14.8693	14.8730	-0.0037	1.00	-8.86E-03	
C101	6-01-90	D6AC	055	8.20	1.500	1.000	0.063	20.98	18.7218	18.7306	-0.0088	1.00	-2.01E-02	-1.12E-02
C101	6-01-90	D6AC	056	8.20	1.500	1.000	0.063	20.98	19.5647	19.5657	-0.0010	1.00	-2.29E-03	
C101	6-01-90	HA 188	007	9.70	1.500	1.000	0.063	20.98	16.4139	16.3203	0.0936	8.00	2.26E-02	2.11E-02
C101	6-01-90	HA 188	034	9.70	1.500	1.000	0.063	20.98	17.1516	17.0705	0.0811	8.00	1.96E-02	
C101	6-01-90	I-718	085	8.60	1.500	1.000	0.063	20.98	16.0171	15.9815	0.0356	8.00	9.71E-03	9.71E-03
C101	6-01-90	I-718	086	8.60	1.500	1.000	0.063	20.98	16.0576	16.0220	0.0356	8.00	9.71E-03	
C101	9-13-90	17-4PH	031	7.80	1.531	1.009	0.065	21.64	15.1862	15.1836	0.0026	6.00	1.01E-03	9.86E-03
C101	9-13-90	17-4PH	032	7.80	1.500	1.002	0.064	21.05	15.2784	15.2316	0.0468	6.00	1.87E-02	
C101	9-13-90	410	053	7.70	1.531	1.013	0.059	21.56	14.5264	14.4742	0.0522	6.00	2.06E-02	1.05E-02
C101	9-13-90	410	054	7.70	1.500	1.010	0.059	21.07	14.3351	14.3344	0.0007	6.00	2.83E-04	
C101	9-13-90	C4340	005	7.84	1.500	0.995	0.062	20.86	14.9894	14.9774	0.0120	6.00	4.82E-03	2.57E-03
C101	9-13-90	C4340	006	7.84	1.500	0.999	0.062	20.94	14.9714	14.9706	0.0008	6.00	3.20E-04	
C101	9-13-90	HA 188	138	9.70	1.500	1.038	0.060	21.65	17.7682	17.7080	0.0602	2.00	5.64E-02	5.70E-02
C101	9-13-90	HA 188	139	9.70	1.531	1.006	0.058	21.40	16.2404	16.1797	0.0607	2.00	5.76E-02	
C101	9-13-90	I-718	066	8.60	1.500	0.995	0.064	20.91	16.2405	16.2316	0.0089	2.00	9.74E-03	1.03E-02
C101	9-13-90	I-718	069	8.60	1.500	0.995	0.061	20.83	15.9554	15.9455	0.0099	2.00	1.09E-02	

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APPENDIX I

STRIPPING RATE DATA FOR THE FIELD TESTING OF McGEAN-ROHCO'S ROSTRIP ELECTROLYTIC STRIPPER 999-SP

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Stripper	Test Date	Coupon Material	Coupon #	Density (g/cm3)	Unwaxed Dimensions --------in inches-------- length	width	thick	Surface Area (cm2)	Initial Mass (grams)	Final Mass (grams)	Change Mass (grams)	Total Time (hours)	Stripping Rate (mil/hr)	Average S.R. (mil/hr)
90 deg. F pH-14.0+ Current-2.0 Amps														
ROSTRIP 999	8-07-90	17-4PH	18	7.80	1.463	1.000	0.064	20.3073	15.1753	15.1752	0.0001	24.00	1.04E-05	5.41E-05
ROSTRIP 999	8-08-90	17-4PH	65	7.80	1.549	1.003	0.063	21.4920	14.8543	14.8533	0.0010	24.00	9.79E-05	
ROSTRIP 999	8-08-90	316	17	8.03	1.574	1.007	0.059	21.8176	13.8154	13.8151	0.0004	24.00	3.43E-05	2.04E-05
ROSTRIP 999	8-08-90	316	18	8.03	1.549	1.001	0.059	21.3587	14.0532	14.0531	0.0001	24.00	6.38E-06	
ROSTRIP 999	8-07-90	410	122	7.70	1.636	1.013	0.060	22.8016	14.6595	14.6239	0.0356	24.00	3.33E-03	3.56E-03
ROSTRIP 999	8-07-90	410	123	7.70	1.612	1.011	0.059	22.4120	14.2121	14.1721	0.0400	24.00	3.80E-03	
ROSTRIP 999	8-06-90	Ag	011	10.50	1.541	0.984	0.123	22.3502	37.9511	35.7631	2.1880	0.50	7.34E+00	6.28E+00
ROSTRIP 999	8-06-90	Ag X	18	10.50	1.537	0.994	0.120	22.4423	37.8564	36.2918	1.5646	0.50	5.23E+00	
ROSTRIP 999	8-09-90	Ag FINAL	011	10.50	1.521	0.981	0.116	21.8595	35.7631	33.4318	2.3313	0.50	8.00E+00	6.10E+00
ROSTRIP 999	8-09-90	AgX FINAL	18	10.50	1.571	0.992	0.117	22.7922	36.2918	35.0120	1.2798	0.50	4.21E+00	
ROSTRIP 999	8-09-90	C4340	23	7.84	1.553	0.993	0.061	21.2912	14.9180	14.9100	0.0080	24.00	7.86E-04	6.99E-04
ROSTRIP 999	8-09-90	C4340	24	7.84	1.584	0.997	0.061	21.7855	14.9893	14.9829	0.0064	24.00	6.11E-04	
ROSTRIP 999	8-09-90	D6AC	82	8.20	1.584	1.001	0.078	22.2637	18.6537	18.6409	0.0128	24.00	1.15E-03	8.15E-04
ROSTRIP 999	8-09-90	D6AC	57	8.20	1.582	1.017	0.070	22.3929	17.5764	17.5710	0.0054	24.00	4.79E-04	
ROSTRIP 999	8-13-90	HA 188	03	9.70	1.539	1.011	0.128	23.0172	36.3539	36.3536	0.0003	2.00	2.65E-04	9.37E-04
ROSTRIP 999	8-13-90	HA 188	02	9.70	1.541	1.015	0.127	23.1080	35.8502	35.8484	0.0018	2.00	1.61E-03	
ROSTRIP 999	8-13-90	I-718	12	8.60	1.500	1.005	0.063	20.8782	16.0995	16.0988	0.0007	2.00	7.67E-04	5.12E-04
ROSTRIP 999	8-13-90	I-718	11	8.60	1.500	1.002	0.064	20.8403	16.0708	16.0706	0.0002	2.00	2.56E-04	
90 deg. F pH-11.0 Current-2.0 Amps														
ROSTRIP 999	7-24-90	17-4PH	8	7.80	1.532	1.000	0.064	21.2261	15.0179	15.0077	0.0102	24.00	1.01E-03	1.20E-03
ROSTRIP 999	7-24-90	17-4PH	9	7.80	1.533	1.000	0.063	21.2166	14.6161	14.6022	0.0139	24.00	1.38E-03	
ROSTRIP 999	7-24-90	316	60	8.03	1.537	1.005	0.058	21.2586	13.8855	13.7377	0.1477	24.00	1.42E-02	6.78E-03
ROSTRIP 999	7-24-90	316	58	8.03	1.621	1.004	0.057	22.3343	13.5893	13.5962	-0.0069	24.00	-6.34E-04	
ROSTRIP 999	7-24-90	410	106	7.70	1.558	1.011	0.058	21.6639	13.7655	13.7708	-0.0052	24.00	-5.15E-04	3.42E-04
ROSTRIP 999	7-24-90	410	105	7.70	1.568	1.020	0.060	22.0335	14.3386	14.3262	0.0124	24.00	1.20E-03	
ROSTRIP 999	7-24-90	Ag	011	10.50	1.541	1.002	0.129	22.8739	43.2207	40.8876	2.3332	0.50	7.65E+00	8.50E+00
ROSTRIP 999	7-24-90	Ag	15	10.50	1.571	1.004	0.118	23.0767	39.1677	36.2880	2.8797	0.50	9.36E+00	
ROSTRIP 999	7-26-90	Ag FINAL	011	10.50	1.546	1.001	0.130	22.9440	40.8876	38.0678	2.8198	0.50	9.22E+00	8.96E+00
ROSTRIP 999	7-26-90	Ag FINAL	15	10.50	1.574	0.996	0.116	22.8971	36.2880	33.6326	2.6554	0.50	8.70E+00	
ROSTRIP 999	7-24-90	Ag F.(RC)	15	10.50	1.574	0.996	0.116	22.8971	36.2880	33.4607	2.8273	0.50	9.26E+00	9.43E+00
ROSTRIP 999	7-24-90	Ag F.(RC)	011	10.50	1.546	1.001	0.130	22.9440	40.8876	37.9511	2.9365	0.50	9.60E+00	
ROSTRIP 999	7-24-90	C4340	3	7.84	1.592	0.995	0.062	21.8720	14.6689	14.6677	0.0012	24.00	1.12E-04	5.53E-04
ROSTRIP 999	7-24-90	C4340	1	7.84	1.553	0.998	0.061	21.3953	15.0242	15.0140	0.0102	24.00	9.94E-04	
ROSTRIP 999	7-24-90	D6AC	100	8.20	1.557	1.010	0.083	22.2066	20.5611	20.5549	0.0062	24.00	5.59E-04	3.27E-05
ROSTRIP 999	7-24-90	D6AC	101	8.20	1.593	1.031	0.076	22.9841	18.5707	18.5764	-0.0057	24.00	-4.93E-04	
ROSTRIP 999	7-26-90	HA 188	115	9.70	1.539	1.011	0.060	21.4549	17.2568	15.6061	1.6507	2.00	1.56E+00	9.85E-01
ROSTRIP 999	7-26-90	HA 188	114	9.70	1.554	1.003	0.060	21.4898	16.8159	16.3829	0.4330	2.00	4.09E-01	
ROSTRIP 999	7-26-90	I-718	43	8.60	1.599	1.001	0.063	22.1165	16.1757	14.8733	1.3024	2.00	1.35E+00	1.23E+00
ROSTRIP 999	7-26-90	I-718	45	8.60	1.552	1.005	0.063	21.5737	16.0283	14.9719	1.0564	2.00	1.12E+00	
90 deg. F pH-12.0 Current-2.0 Amps														
ROSTRIP 999	7-31-90	17-4PH	61	7.80	1.561	1.007	0.063	21.7360	15.2225	15.2278	-0.0053	24.00	-5.16E-04	-7.19E-04
ROSTRIP 999	7-31-90	17-4PH	60	7.80	1.527	1.007	0.063	21.2804	15.1555	15.1648	-0.0093	24.00	-9.22E-04	

Stripper	Test Date	Coupon Material	Coupon #	Density (g/cm3)	Unwaxed Dimensions in inches length	width	thick	Surface Area (cm2)	Initial Mass (grams)	Final Mass (grams)	Change Mass (grams)	Total Time (hours)	Stripping Rate (mil/hr)	Average S.R. (mil/hr)
ROSTRIP 999	8-01-90	316	85	8.03	1.500	1.003	0.059	20.7474	14.2223	14.2215	0.0008	24.00	7.55E-05	1.55E-03
ROSTRIP 999	8-01-90	316	86	8.03	1.573	1.003	0.058	21.6969	14.1108	14.0787	0.0321	24.00	3.02E-03	
ROSTRIP 999	7-31-90	410	92	7.70	1.559	1.019	0.060	21.8907	14.6724	14.6663	0.0061	24.00	5.97E-04	5.15E-04
ROSTRIP 999	7-31-90	410	91	7.70	1.567	1.014	0.058	21.8476	13.8947	13.8903	0.0044	24.00	4.32E-04	
ROSTRIP 999	7-31-90	Ag	14	10.50	1.525	0.979	0.121	21.9831	37.1085	33.8835	3.2249	0.50	1.10E+01	1.02E+01
ROSTRIP 999	7-31-90	Ag	15	10.50	1.546	0.993	0.119	22.5204	37.8110	34.9640	2.8471	0.50	9.48E+00	
ROSTRIP 999	8-03-90	Ag FINAL	14	10.50	1.525	0.965	0.119	21.6412	33.8835	30.9620	2.9215	0.50	1.01E+01	1.04E+01
ROSTRIP 999	8-03-90	Ag FINAL	15	10.50	1.546	0.978	0.118	22.1755	34.9640	31.7791	3.1849	0.50	1.08E+01	
ROSTRIP 999	7-31-90	C4340	40	7.84	1.559	1.032	0.061	22.1856	15.3598	15.3482	0.0116	24.00	1.09E-03	5.62E-04
ROSTRIP 999	8-01-90	C4340	41	7.84	1.559	0.999	0.060	21.4729	14.7167	14.7163	0.0003	24.00	3.25E-05	
ROSTRIP 999	7-31-90	D6AC	141	8.20	1.561	1.011	0.077	22.1434	19.1955	19.1789	0.0166	24.00	1.50E-03	9.38E-04
ROSTRIP 999	8-01-90	D6AC	142	8.20	1.570	1.005	0.070	21.9761	17.2340	17.2298	0.0042	24.00	3.79E-04	
ROSTRIP 999	8-02-90	HA 188	149	9.70	1.561	1.000	0.059	21.4974	16.4129	13.9077	2.5052	2.00	2.36E+00	1.18E+00
ROSTRIP 999	8-02-90	HA 188	148	9.70	1.559	1.005	0.059	21.5752	16.9635	16.9629	0.0006	2.00	5.33E-04	
ROSTRIP 999	8-02-90	I-718	12	8.60	1.629	1.004	0.063	22.5817	15.9124	14.7243	1.1881	2.00	1.20E+00	1.41E+00
ROSTRIP 999	8-02-90	I-718	13	8.60	1.572	1.004	0.063	21.8201	16.1775	14.6279	1.5496	2.00	1.63E+00	
115 deg. F pH-14.0 Current-2.0 Amps														
ROSTRIP 999	7-13-90	17-4PH	81	7.80	1.545	1.004	0.063	21.4593	14.9466	14.9352	0.0114	24.00	1.12E-03	1.70E-03
ROSTRIP 999	7-13-90	17-4PH	77	7.80	1.566	1.015	0.064	21.9943	15.3566	15.3327	0.0239	24.00	2.29E-03	
ROSTRIP 999	7-11-90	316	6	8.03	1.535	1.003	0.058	21.1908	13.8910	13.8521	0.0390	24.00	3.76E-03	2.55E-03
ROSTRIP 999	7-11-90	316	5	8.03	1.565	1.001	0.058	21.5484	13.8884	13.8743	0.0141	24.00	1.34E-03	
ROSTRIP 999	7-11-90	410	111	7.70	1.555	1.014	0.059	21.7092	14.0227	14.0210	0.0018	24.00	1.73E-04	2.18E-04
ROSTRIP 999	7-11-90	410	124	7.70	1.545	1.015	0.059	21.5953	14.2308	14.2282	0.0027	24.00	2.63E-04	
ROSTRIP 999	7-10-90	Ag	2	10.50	1.550	0.998	0.121	22.7281	39.9341	35.2938	4.6403	0.50	1.53E+01	1.60E+01
ROSTRIP 999	7-10-90	Ag	4	10.50	1.520	0.950	0.091	20.6401	27.8583	23.2409	4.6174	0.50	1.68E+01	
ROSTRIP 999	7-18-90	Ag FINAL X	5X	10.50	1.563	0.987	0.118	22.5982	35.8039	32.1264	3.6775	0.50	1.22E+01	1.16E+01
ROSTRIP 999	7-18-90	Ag FINAL X	4X	10.50	1.562	0.986	0.122	22.6542	35.4413	32.1265	3.3148	0.50	1.10E+01	
ROSTRIP 999	7-11-90	C4340	82	7.84	1.546	0.998	0.062	21.3306	14.7760	14.7293	0.0467	24.00	4.58E-03	5.78E-03
ROSTRIP 999	7-11-90	C4340	81	7.84	1.580	0.998	0.063	21.7997	15.2371	15.1643	0.0728	24.00	6.99E-03	
ROSTRIP 999	7-11-90	D6AC	89	8.20	1.555	1.011	0.078	22.0852	18.7552	18.7152	0.0400	24.00	3.62E-03	3.54E-03
ROSTRIP 999	7-11-90	D6AC	75	8.20	1.564	1.007	0.077	22.0993	18.4863	18.4481	0.0382	24.00	3.46E-03	
ROSTRIP 999	7-13-90	HA 188	20	9.70	1.582	1.010	0.059	21.9881	16.8862	14.8112	2.0750	2.00	1.92E+00	1.78E+00
ROSTRIP 999	7-13-90	HA 188	19	9.70	1.596	1.002	0.059	22.0050	16.8848	15.0927	1.7921	2.00	1.65E+00	
ROSTRIP 999	7-13-90	I-718	60	8.60	1.579	1.000	0.063	21.8288	16.0036	14.1723	1.8313	2.00	1.92E+00	1.38E+00
ROSTRIP 999	7-13-90	I-718	62	8.60	1.589	1.013	0.062	22.2157	16.0655	15.2590	0.8065	2.00	8.31E-01	
90 deg. F pH-14.0 Current-2.0 Amps Longevity Test														
ROSTRIP 999	7-10-90	17-4 PH	73	7.80	1.562	1.005	0.062	21.6844	14.9567	14.9031	0.0536	2.00	6.24E-02	5.78E-03
ROSTRIP 999	7-10-90	17-4 PH	74	7.80	1.555	1.007	0.063	21.6556	15.2187	15.2157	0.0029	2.00	3.42E-03	
ROSTRIP 999	7-10-90	Ag X	5X	10.50	1.545	0.995	0.123	22.6410	38.9955	35.8031	3.1924	0.50	1.06E+01	3.54E-03
ROSTRIP 999	7-10-90	Ag X	4X	10.50	1.562	0.998	0.125	22.9838	38.9036	35.4405	3.4631	0.50	1.13E+01	
ROSTRIP 999	7-10-90	HA 188	17	9.70	1.550	1.002	0.059	21.3928	16.5116	12.9069	3.6048	2.00	3.42E+00	1.78E+00
ROSTRIP 999	7-10-90	HA 188	16	9.70	1.560	1.003	0.059	21.5468	17.0150	13.6857	3.3293	2.00	3.14E+00	
ROSTRIP 999	7-10-90	I-718	59	8.60	1.550	1.004	0.063	21.5261	16.0573	14.0270	2.0303	2.00	2.16E+00	1.38E+00
ROSTRIP 999	7-10-90	I-718	63	8.60	1.560	1.003	0.063	21.6388	16.1496	13.4900	2.6596	2.00	2.81E+00	

APPENDIX J

STRIPPING RATE DATA FOR THE FIELD TESTING OF TECHNIC'S NON-CYANIDE SILVER STRIPPER (ELECTROLYTIC)

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Stripper	Test Date	Coupon Material	Coupon Number	Density (g/cm3)	Unwaxed Dimensions in inches length	width	thick	Surface Area (cm2)	Initial Mass (grams)	Final Mass (grams)	Change Mass (grams)	Total Time (hours)	Stripping Rate (mil/hr)	Average S.R. (mil/hr)
90 deg. F pH-9.0 Voltage-4.5 Volts														
TECHNIC Ag	7-24-90	17-4PH	7	7.80	1.559	0.999	0.062	21.5188	14.8466	14.8498	-0.0032	24.00	-3.09E-04	-3.48E-04
TECHNIC Ag	7-24-90	17-4PH	6	7.80	1.476	1.004	0.061	20.4924	14.7040	14.7077	-0.0038	24.00	-3.87E-04	
TECHNIC Ag	7-24-90	316	62	8.03	1.559	1.004	0.058	21.5313	14.1606	14.1587	0.0019	24.00	1.77E-04	5.51E-04
TECHNIC Ag	7-24-90	316	55	8.03	1.565	0.999	0.058	21.5066	13.8567	13.8470	0.0097	24.00	9.25E-04	
TECHNIC Ag	7-24-90	410	107	7.70	1.598	1.023	0.060	22.5041	14.4155	14.4141	0.0014	24.00	1.29E-04	5.52E-05
TECHNIC Ag	7-24-90	410	108	7.70	1.588	1.030	0.058	22.4700	14.3379	14.3381	-0.0002	24.00	-1.90E-05	
TECHNIC Ag	7-24-90	Ag	13	10.50	1.570	0.997	0.122	23.0025	39.2786	39.0861	0.1925	0.50	6.28E-01	7.11E-01
TECHNIC Ag	7-24-90	Ag	12	10.50	1.515	0.997	0.120	22.2063	38.0123	37.7772	0.2350	0.50	7.94E-01	
TECHNIC Ag	7-26-90	Ag FINAL	12	10.50	1.556	1.000	0.120	22.8304	37.7772	37.6342	0.1430	0.50	4.70E-01	4.56E-01
TECHNIC Ag	7-26-90	Ag FINAL	13	10.50	1.564	0.999	0.124	23.0100	39.0861	38.9502	0.1358	0.50	4.43E-01	
TECHNIC Ag	7-24-90	C4340	99	7.84	1.581	0.998	0.061	21.7669	14.5711	14.5726	-0.0016	24.00	-1.51E-04	-2.05E-04
TECHNIC Ag	7-24-90	C4340	100	7.84	1.599	1.000	0.062	22.0718	14.8641	14.8668	-0.0027	24.00	-2.59E-04	
TECHNIC Ag	7-24-90	D6AC	102	8.20	1.573	1.004	0.082	22.2724	19.9662	19.9705	-0.0043	24.00	-3.86E-04	-2.14E-04
TECHNIC Ag	7-24-90	D6AC	103	8.20	1.552	1.033	0.074	22.4139	18.5127	18.5132	-0.0005	24.00	-4.17E-05	
TECHNIC Ag	7-26-90	HA 188	90	9.70	1.505	1.004	0.127	22.3754	35.9759	35.4694	0.5066	2.00	4.59E-01	4.84E-01
TECHNIC Ag	7-26-90	HA 188	116	9.70	1.595	1.000	0.060	21.9722	16.9302	16.3786	0.5516	2.00	5.09E-01	
TECHNIC Ag	7-26-90	I-718	40	8.60	1.575	1.001	0.063	21.7967	15.9719	15.9689	0.0030	2.00	3.15E-03	2.29E-03
TECHNIC Ag	7-26-90	I-718	41	8.60	1.585	1.001	0.063	21.9300	16.1956	16.1943	0.0014	2.00	1.43E-03	
90 deg. F pH-10.0 Voltage-4.5 Volts														
TECHNIC Ag	7-31-90	17-4PH	58	7.80	1.565	1.007	0.064	21.8126	15.2908	15.2887	0.0021	24.00	2.06E-04	3.24E-04
TECHNIC Ag	7-31-90	17-4PH	59	7.80	1.554	0.999	0.061	21.4294	14.6939	14.6894	0.0045	24.00	4.42E-04	
TECHNIC Ag	7-31-90	316	57	8.03	1.535	1.006	0.058	21.2525	13.9390	13.9338	0.0052	24.00	4.97E-04	3.82E-04
TECHNIC Ag	7-31-90	316	56	8.03	1.563	1.004	0.059	21.6077	14.1810	14.1782	0.0028	24.00	2.68E-04	
TECHNIC Ag	7-31-90	410	95	7.70	1.570	1.018	0.059	21.9953	14.2548	14.2514	0.0035	24.00	3.36E-04	2.28E-04
TECHNIC Ag	7-31-90	410	94	7.70	1.582	1.040	0.059	22.6233	14.7552	14.7539	0.0013	24.00	1.19E-04	
TECHNIC Ag	7-31-90	Ag X	20	10.50	1.571	0.998	0.129	23.1990	41.9410	41.6304	0.3105	0.50	1.00E+00	1.01E+00
TECHNIC Ag	7-31-90	Ag X	19	10.50	1.581	0.995	0.131	23.3160	42.8706	42.5534	0.3172	0.50	1.02E+00	
TECHNIC Ag	8-03-90	AgX FINAL	19	10.50	1.586	0.994	0.130	23.3392	42.5534	42.2467	0.3067	0.50	9.86E-01	9.16E-01
TECHNIC Ag	8-03-90	AgX FINAL	20	10.50	1.586	0.994	0.128	23.2931	41.6304	41.3675	0.2629	0.50	8.46E-01	
TECHNIC Ag	7-31-90	C4340	39	7.84	1.575	1.000	0.061	21.7295	14.8865	14.8832	0.0033	24.00	3.18E-04	6.00E-04
TECHNIC Ag	8-01-90	C4340	38	7.84	1.552	1.000	0.062	21.4466	14.7498	14.7407	0.0090	24.00	8.81E-04	
TECHNIC Ag	7-31-90	D6AC	139	8.20	1.561	1.011	0.084	22.3052	20.6326	20.6283	0.0042	24.00	3.80E-04	5.70E-04
TECHNIC Ag	8-01-90	D6AC	140	8.20	1.590	1.026	0.078	22.8823	19.5672	19.5585	0.0087	24.00	7.61E-04	
TECHNIC Ag	8-02-90	HA 188	145	9.70	1.577	0.961	0.063	20.9769	16.8188	16.2738	0.5450	2.00	5.27E-01	4.03E-01
TECHNIC Ag	8-02-90	HA 188	146	9.70	1.601	1.002	0.063	22.1646	16.9636	16.6585	0.3051	2.00	2.79E-01	
TECHNIC Ag	8-02-90	I-718	10	8.60	1.593	1.003	0.059	21.9864	16.1792	16.1760	0.0032	2.00	3.30E-03	2.97E-03
TECHNIC Ag	8-02-90	I-718	11	8.60	1.500	1.003	0.060	20.7700	16.0631	16.0607	0.0024	2.00	2.64E-03	
90 deg. F pH-12.0 Voltage-4.5 Volts														
TECHNIC Ag	8-07-90	17-4PH	16	7.80	1.501	1.008	0.064	20.9748	15.2707	15.2693	0.0014	24.00	1.37E-04	1.73E-04
TECHNIC Ag	8-07-90	17-4PH	17	7.80	1.543	1.004	0.063	21.4326	14.8770	14.8749	0.0021	24.00	2.09E-04	
TECHNIC Ag	8-07-90	316	74	8.03	1.566	1.006	0.059	21.6896	13.8910	13.8891	0.0019	24.00	1.76E-04	2.80E-04
TECHNIC Ag	8-09-90	316	08	8.03	1.530	1.012	0.055	21.2399	13.7390	13.7350	0.0040	24.00	3.85E-04	
TECHNIC Ag	8-07-90	410	120	7.70	1.583	1.021	0.060	22.2579	14.7872	14.7858	0.0014	24.00	1.34E-04	1.33E-04

Stripper	Test Date	Coupon Material	Coupon Number	Density (g/cm3)	Unwaxed Dimensions in inches length	width	thick	Surface Area (cm2)	Initial Mass (grams)	Final Mass (grams)	Change Mass (grams)	Total Time (hours)	Stripping Rate (mil/hr)	Average S.R. (mil/hr)
TECHNIC Ag	8-09-90	410	126	7.70	1.547	1.017	0.059	21.6637	14.4115	14.4102	0.0013	24.00	1.31E-04	
TECHNIC Ag	8-07-90	Ag	10	10.50	1.586	0.992	0.116	22.9725	36.2267	35.7398	0.4869	0.50	1.59E+00	1.92E+00
TECHNIC Ag	8-07-90	Ag	001	10.50	1.472	0.999	0.116	21.5714	38.0309	37.3842	0.6467	0.50	2.25E+00	
TECHNIC Ag	8-09-90	Ag FINAL	10	10.50	1.529	0.990	0.116	22.1578	35.7398	35.6550	0.0848	0.50	2.87E-01	3.53E-01
TECHNIC Ag	8-09-90	Ag FINAL	001	10.50	1.561	0.999	0.115	22.7623	37.3842	37.2569	0.1273	0.50	4.19E-01	
TECHNIC Ag	8-07-90	C4340	26	7.84	1.587	0.993	0.061	21.7402	14.7730	14.7698	0.0033	24.00	3.14E-04	2.80E-04
TECHNIC Ag	8-07-90	C4340	25	7.84	1.570	0.997	0.060	21.5769	14.5718	14.5693	0.0025	24.00	2.46E-04	
TECHNIC Ag	8-07-90	D6AC	83	8.20	1.517	1.009	0.071	21.3696	17.6377	17.6309	0.0068	24.00	6.37E-04	4.76E-04
TECHNIC Ag	8-07-90	D6AC	84	8.20	1.572	0.999	0.085	22.2213	21.2584	21.2549	0.0035	24.00	3.15E-04	
TECHNIC Ag	8-10-90	HA188	103	9.70	1.575	1.002	0.060	21.7486	17.2728	16.6803	0.5925	2.00	5.53E-01	7.30E-01
TECHNIC Ag	8-10-90	HA188	102	9.70	1.545	1.002	0.060	21.3491	17.2059	16.2518	0.9540	2.00	9.07E-01	
TECHNIC Ag	8-10-90	I-718	16	8.60	1.500	0.996	0.062	20.6742	16.0849	16.0853	-0.0003	2.00	-3.69E-04	9.58E-04
TECHNIC Ag	8-10-90	I-718	17	8.60	1.568	1.001	0.063	21.7119	16.1659	16.1637	0.0022	2.00	2.28E-03	
115 deg. F pH-10.0 Voltage-4.5 Volts														
TECHNIC Ag	7-12-90	17-4PH	82	7.80	1.481	1.007	0.063	20.6640	14.9262	14.9208	0.0054	24.00	5.46E-04	7.22E-04
TECHNIC Ag	7-12-90	17-4PH	83	7.80	1.460	0.998	0.064	20.2280	15.1323	15.1236	0.0086	24.00	8.98E-04	
TECHNIC Ag	7-12-90	316	10	8.03	1.439	1.002	0.057	19.8710	13.6049	13.6006	0.0043	24.00	4.42E-04	3.11E-04
TECHNIC Ag	7-12-90	316	7	8.03	1.480	1.002	0.058	20.4386	13.7170	13.7152	0.0018	24.00	1.80E-04	
TECHNIC Ag	7-12-90	410	117	7.70	1.430	1.028	0.059	20.2951	14.3414	14.3390	0.0025	24.00	2.59E-04	4.90E-04
TECHNIC Ag	7-12-90	410	116	7.70	1.439	1.016	0.059	20.1860	14.2302	14.2233	0.0068	24.00	7.21E-04	
TECHNIC Ag	7-18-90	Ag FINAL X	8X	10.50	1.591	0.987	0.120	23.0221	37.9779	37.8918	0.0861	0.50	2.80E-01	2.76E-01
TECHNIC Ag	7-18-90	Ag FINAL X	9X	10.50	1.573	1.002	0.122	23.1528	38.1422	38.0580	0.0841	0.50	2.73E-01	
TECHNIC Ag	7-10-90	Ag X	8X	10.50	1.572	0.994	0.120	22.9183	38.2154	37.9774	0.2380	0.50	7.79E-01	7.08E-01
TECHNIC Ag	7-10-90	Ag X	9X	10.50	1.568	1.003	0.123	23.1291	38.3388	38.1422	0.1966	0.50	6.38E-01	
TECHNIC Ag	7-11-90	C4340	71	7.84	1.455	0.993	0.062	20.0191	14.8094	14.8055	0.0039	24.00	4.08E-04	4.55E-04
TECHNIC Ag	7-11-90	C4340	70	7.84	1.455	0.997	0.063	20.1197	15.0404	15.0355	0.0048	24.00	5.03E-04	
TECHNIC Ag	7-11-90	D6AC	72	8.20	1.465	1.012	0.083	20.9983	20.5462	20.5453	0.0009	24.00	8.89E-05	3.43E-04
TECHNIC Ag	7-11-90	D6AC	70	8.20	1.458	1.009	0.081	20.7987	19.4225	19.4163	0.0062	24.00	5.96E-04	
TECHNIC Ag	7-16-90	HA188	46	9.70	1.524	1.000	0.060	21.0286	16.8171	16.3138	0.5033	2.00	4.86E-01	5.31E-01
TECHNIC Ag	7-16-90	HA188	43	9.70	1.528	1.003	0.060	21.1432	17.2867	16.6857	0.6010	2.00	5.77E-01	
TECHNIC Ag	7-16-90	I-718	66	8.60	1.475	0.999	0.063	20.4248	16.2453	16.2407	0.0046	2.00	5.19E-03	6.94E-03
TECHNIC Ag	7-16-90	I-718	69	8.60	1.473	0.999	0.062	20.3758	15.9637	15.9560	0.0077	2.00	8.69E-03	
140 deg. F pH-10.0 Voltage-4.5 Volts														
TECHNIC Ag	7-20-90	17-4PH	64	7.80	1.477	0.999	0.063	20.4514	14.9130	14.9080	0.0050	24.00	5.14E-04	2.98E-04
TECHNIC Ag	7-20-90	17-4PH	75	7.80	1.520	1.007	0.064	21.2094	15.2495	15.2487	0.0008	24.00	8.26E-05	
TECHNIC Ag	7-20-90	316	12	8.03	1.510	1.002	0.057	20.8150	13.6661	13.6598	0.0063	24.00	6.15E-04	3.16E-04
TECHNIC Ag	7-20-90	316	11	8.03	1.423	1.006	0.057	19.7346	13.7607	13.7605	0.0002	24.00	1.73E-05	
TECHNIC Ag	7-20-90	410	114	7.70	1.493	1.020	0.060	21.0174	14.6962	14.6924	0.0038	24.00	3.82E-04	3.96E-04
TECHNIC Ag	7-20-90	410	115	7.70	1.452	1.011	0.060	20.2863	14.5507	14.5468	0.0039	24.00	4.10E-04	
TECHNIC Ag	7-20-90	Ag	13	10.50	1.575	0.992	0.130	23.1449	42.3868	42.0679	0.3189	0.50	1.03E+00	1.08E+00
TECHNIC Ag	7-20-90	Ag	12	10.50	1.574	1.006	0.117	23.1383	39.3712	39.0226	0.3486	0.50	1.13E+00	
TECHNIC Ag	7-23-90	Ag FINAL	13	10.50	1.575	0.994	0.130	23.1889	42.0679	41.7617	0.3062	0.50	9.90E-01	9.47E-01
TECHNIC Ag	7-23-90	Ag FINAL	12	10.50	1.574	1.004	0.119	23.1409	39.0226	38.7438	0.2788	0.50	9.03E-01	
TECHNIC Ag	7-20-90	C4340	73	7.84	1.467	0.994	0.060	20.1528	14.4735	14.4679	0.0055	24.00	5.74E-04	9.67E-04
TECHNIC Ag	7-20-90	C4340	74	7.84	1.496	0.993	0.062	20.5609	14.8783	14.8649	0.0134	24.00	1.36E-03	

Stripper	Test Date	Coupon Material	Coupon Number	Density (g/cm3)	Unwaxed Dimensions in inches length	width	thick	Surface Area (cm2)	Initial Mass (grams)	Final Mass (grams)	Change Mass (grams)	Total Time (hours)	Stripping Rate (mil/hr)	Average S.R. (mil/hr)
TECHNIC Ag	7-20-90	D6AC	71	8.20	1.434	1.009	0.082	20.4959	19.5102	19.4983	0.0119	24.00	1.16E-03	9.19E-04
TECHNIC Ag	7-20-90	D6AC	69	8.20	1.521	1.006	0.071	21.3619	17.3133	17.3060	0.0073	24.00	6.81E-04	
TECHNIC Ag	7-23-90	HA188	88	9.70	1.500	1.009	0.127	22.4115	36.0262	35.6269	0.3993	2.00	3.62E-01	4.24E-01
TECHNIC Ag	7-23-90	HA188	85	9.70	1.487	1.011	0.127	22.2732	36.6310	36.0979	0.5331	2.00	4.86E-01	
TECHNIC Ag	7-23-90	I-718	51	8.60	1.478	1.000	0.063	20.4846	16.0992	16.0956	0.0036	2.00	4.02E-03	6.90E-03
TECHNIC Ag	7-23-90	I-718	53	8.60	1.512	1.000	0.062	20.9144	16.0199	16.0110	0.0089	2.00	9.78E-03	
90 deg. F pH-10.0 Voltage-4.5 Volts Longevity Test														
TECHNIC Ag	7-10-90	Ag	8	10.50	1.545	0.995	0.129	22.7778	42.0613	41.7567	0.3046	0.50	1.00E+00	1.00E+00
TECHNIC Ag	7-10-90	Ag	7	10.50	1.560	0.995	0.128	22.9600	41.6422	41.3345	0.3077	0.50	1.01E+00	
TECHNIC Ag	7-10-90	HA188	42	9.70	1.491	1.005	0.061	20.7127	17.1132	16.5284	0.5847	2.00	5.73E-01	5.73E-01
TECHNIC Ag	7-10-90	HA188	45	9.70	1.502	0.998	0.061	20.7185	17.4090	16.8239	0.5850	2.00	5.73E-01	
TECHNIC Ag	7-10-90	I-718	68	8.60	1.503	0.995	0.062	20.6937	15.8173	15.3829	0.4344	2.00	4.81E-01	2.94E-01
TECHNIC Ag	7-10-90	I-718	67	8.60	1.500	1.004	0.063	20.8580	16.2869	16.1882	0.0987	2.00	1.08E-01	

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APPENDIX K

STRIPPING RATE DATA FOR THE FIELD TESTING OF TECHNIC'S CY-LESS ELECTROLYTIC GOLD STRIP

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Stripper	Test Date	Coupon Material	Coupon #	Density (g/cm3)	Unwaxed Dimensions in inches length	width	thick	Surface Area (cm2)	Initial Mass (grams)	Final Mass (grams)	Change Mass (grams)	Total Time (hours)	Stripping Rate (mil/hr)	Average S.R. (mil/hr)
90 deg. F pH-2.0 Current-0.2 Amps														
CYLESS Au	7-24-90	17-4PH	4	7.80	1.578	1.009	0.065	22.05	15.3217	15.3158	0.0059	24.0	5.66E-04	1.16E-03
CYLESS Au	7-24-90	17-4PH	5	7.80	1.562	1.005	0.063	21.71	14.5265	14.5084	0.0181	24.0	1.75E-03	
CYLESS Au	7-24-90	316	63	8.03	1.555	1.004	0.059	21.50	13.9899	13.9891	0.0007	24.0	6.97E-05	1.41E-03
CYLESS Au	7-24-90	316	61	8.03	1.597	1.009	0.059	22.17	14.1007	14.0708	0.0299	24.0	2.75E-03	
CYLESS Au	7-24-90	410	103	7.70	1.558	1.018	0.060	21.86	14.6944	14.6858	0.0086	24.0	8.42E-04	1.15E-03
CYLESS Au	7-24-90	410	104	7.70	1.584	1.018	0.060	22.21	14.6009	14.5857	0.0152	24.0	1.46E-03	
CYLESS Au	7-24-90	Ag	10	10.50	1.569	0.990	0.122	22.84	38.7862	38.1466	0.6396	0.5	2.10E+00	2.29E+00
CYLESS Au	7-24-90	Ag	11	10.50	1.575	0.991	0.120	22.89	38.4943	37.7371	0.7572	0.5	2.48E+00	
CYLESS Au	7-26-90	Ag FINAL	11	10.50	1.581	0.994	0.119	23.02	37.7371	37.2611	0.4760	0.5	1.55E+00	1.50E+00
CYLESS Au	7-26-90	Ag FINAL	10	10.50	1.571	0.997	0.121	22.99	38.1466	37.7008	0.4458	0.5	1.45E+00	
CYLESS Au	7-24-90	C4340	2	7.84	1.649	1.001	0.062	22.76	15.0668	14.4694	0.5975	24.0	5.49E-02	3.04E-02
CYLESS Au	7-24-90	C4340	4	7.84	1.594	0.999	0.061	21.96	14.7213	14.6596	0.0617	24.0	5.88E-03	
CYLESS Au	7-24-90	D6AC	104	8.20	1.606	1.016	0.084	23.03	20.8098	20.5791	0.2307	24.0	2.00E-02	2.05E-02
CYLESS Au	7-24-90	D6AC	105	8.20	1.573	1.024	0.081	22.68	20.2191	19.9821	0.2370	24.0	2.09E-02	
CYLESS Au	7-26-90	HA 188	113	9.70	1.603	1.003	0.060	22.14	17.0690	16.3589	0.7101	2.0	6.51E-01	6.55E-01
CYLESS Au	7-26-90	HA 188	112	9.70	1.597	1.002	0.060	22.04	17.1790	16.4633	0.7156	2.0	6.59E-01	
CYLESS Au	7-26-90	I-718	44	8.60	1.602	1.001	0.063	22.16	16.3818	16.1327	0.2491	2.0	2.57E-01	3.87E-01
CYLESS Au	7-26-90	I-718	42	8.60	1.584	1.000	0.063	21.90	16.1765	15.6814	0.4950	2.0	5.18E-01	
90 deg. F pH-4.5 Current-0.2 Amps														
CYLESS Au	7-31-90	17-4PH	57	7.80	1.503	1.001	0.064	20.86	15.1798	15.1522	0.0276	24.0	2.79E-03	2.09E-03
CYLESS Au	7-31-90	17-4PH	56	7.80	1.530	1.001	0.064	21.22	14.8959	14.8818	0.0141	24.0	1.40E-03	
CYLESS Au	7-31-90	316	84	8.03	1.551	1.005	0.058	21.45	13.9327	13.8857	0.0470	24.0	4.48E-03	3.74E-03
CYLESS Au	7-31-90	316	83	8.03	1.553	1.005	0.059	21.50	13.9726	13.9410	0.0316	24.0	3.00E-03	
CYLESS Au	7-31-90	410	97	7.70	1.535	1.004	0.059	21.23	14.0573	14.0249	0.0324	24.0	3.25E-03	3.27E-03
CYLESS Au	7-31-90	410	98	7.70	1.530	1.017	0.059	21.43	14.0511	14.0180	0.0331	24.0	3.29E-03	
CYLESS Au	7-31-90	Ag X	17	10.50	1.573	0.972	0.122	22.50	36.9820	36.7799	0.2020	0.5	6.73E-01	5.92E-01
CYLESS Au	7-31-90	Ag X	18	10.50	1.567	0.998	0.122	22.98	38.6412	38.4850	0.1562	0.5	5.10E-01	
CYLESS Au	7-31-90	AgX FINAL	8	10.50	1.541	0.996	0.128	22.72	41.7570	40.6860	1.0711	0.5	3.53E+00	3.11E+00
CYLESS Au	7-31-90	AgX FINAL	7	10.50	1.528	0.995	0.127	22.50	41.3344	40.5296	0.8048	0.5	2.68E+00	
CYLESS Au	7-31-90	Ag X (RC)	17	10.50	1.573	0.972	0.122	22.50	36.9820	36.4615	0.5204	0.5	1.73E+00	2.15E+00
CYLESS Au	7-31-90	Ag X (RC)	18	10.50	1.567	0.998	0.122	22.98	38.6412	37.8564	0.7848	0.5	2.56E+00	
CYLESS Au	7-31-90	C4340	83	7.84	1.580	1.003	0.060	21.84	14.6469	14.4916	0.1553	24.0	1.49E-02	1.06E-02
CYLESS Au	8-01-90	C4340	43	7.84	1.606	1.001	0.060	22.14	14.6421	14.5755	0.0666	24.0	6.30E-03	
CYLESS Au	7-31-90	D6AC	137	8.20	1.587	1.010	0.085	22.66	20.9479	20.7475	0.2005	24.0	1.77E-02	9.81E-03
CYLESS Au	8-01-90	D6AC	136	8.20	1.574	1.020	0.083	22.65	20.2615	20.2398	0.0217	24.0	1.92E-03	
CYLESS Au	8-02-90	HA 188	111	9.70	1.608	0.999	0.060	22.12	17.2150	16.3034	0.9116	2.0	8.36E-01	7.20E-01
CYLESS Au	8-02-90	HA 188	147	9.70	1.625	1.004	0.059	22.43	16.8100	16.1429	0.6671	2.0	6.03E-01	
CYLESS Au	8-02-90	I-718	39	8.60	1.595	0.991	0.062	21.83	15.9319	15.9122	0.0197	2.0	2.06E-02	3.41E-02
CYLESS Au	8-02-90	I-718	57	8.60	1.592	1.003	0.063	22.07	16.1528	16.1069	0.0459	2.0	4.76E-02	
90 deg. F pH-6.0 Current-0.2 Amps														
CYLESS Au	8-09-90	17-4PH	62	7.80	1.551	1.018	0.062	21.81	15.1662	15.1493	0.0169	24.0	1.63E-03	3.69E-03
CYLESS Au	8-09-90	17-4PH	63	7.80	1.559	1.000	0.062	21.54	14.6943	14.6355	0.0588	24.0	5.74E-03	

Stripper	Test Date	Coupon Material	Coupon #	Density (g/cm3)	Unwaxed Dimensions in inches length	width	thick	Surface Area (cm2)	Initial Mass (grams)	Final Mass (grams)	Change Mass (grams)	Total Time (hours)	Stripping Rate (mil/hr)	Average S.R. (mil/hr)
CYLESS Au	8-07-90	316	14	8.03	1.557	1.004	0.058	21.50	14.0586	14.0347	0.0239	24.0	2.27E-03	3.48E-03
CYLESS Au	8-07-90	316	59	8.03	1.553	1.003	0.058	21.43	13.8061	13.7569	0.0492	24.0	4.69E-03	
CYLESS Au	8-07-90	410	118	7.70	1.568	1.021	0.060	22.05	14.5233	14.5026	0.0206	24.0	1.99E-03	1.33E-03
CYLESS Au	8-07-90	410	119	7.70	1.585	1.018	0.059	22.20	14.1504	14.1435	0.0069	24.0	6.59E-04	
CYLESS Au	8-07-90	Ag	11	10.50	1.545	0.993	0.116	22.44	36.7901	36.4043	0.3858	0.5	1.29E+00	1.51E+00
CYLESS Au	8-07-90	Ag X	17	10.50	1.597	0.971	0.121	22.77	36.4615	35.9362	0.5253	0.5	1.73E+00	
CYLESS Au	8-09-90	Ag FINAL	14	10.50	1.525	0.942	0.112	21.00	30.9620	29.8886	1.0735	0.5	3.83E+00	3.81E+00
CYLESS Au	8-09-90	Ag FINAL	15	10.50	1.544	0.963	0.111	21.67	31.7791	30.6862	1.0929	0.5	3.78E+00	
CYLESS Au	8-07-90	C4340	27	7.84	1.580	0.995	0.062	21.71	14.9757	14.9730	0.0027	24.0	2.57E-04	1.20E-03
CYLESS Au	8-07-90	C4340	28	7.84	1.582	0.997	0.059	21.71	14.5588	14.5366	0.0222	24.0	2.14E-03	
CYLESS Au	8-07-90	D6AC	144	8.20	1.647	0.994	0.076	22.91	18.5084	18.4961	0.0123	24.0	1.08E-03	9.27E-04
CYLESS Au	8-07-90	D6AC	143	8.20	1.647	0.957	0.070	21.95	16.3285	16.3200	0.0085	24.0	7.78E-04	
CYLESS Au	8-08-90	HA 188	105	9.70	1.551	0.997	0.060	21.33	17.2209	16.4567	0.7642	2.0	7.27E-01	8.41E-01
CYLESS Au	8-08-90	HA 188	104	9.70	1.557	1.001	0.059	21.47	16.9946	15.9846	1.0100	2.0	9.55E-01	
CYLESS Au	8-08-90	I-718	19	8.60	1.540	0.996	0.063	21.23	16.2556	16.2430	0.0126	2.0	1.36E-02	2.21E-02
CYLESS Au	8-08-90	I-718	20	8.60	1.572	0.995	0.062	21.61	16.0169	15.9880	0.0289	2.0	3.07E-02	
115 deg. F	pH-4.5	Current-0.2 Amps												
CYLESS Au	7-12-90	17-4PH	79	7.80	1.565	1.000	0.063	21.64	14.7077	14.6329	0.0748	24.0	7.27E-03	7.27E-03
CYLESS Au	7-12-90	17-4PH											NOT TESTED	
CYLESS Au	7-12-90	316	4	8.03	1.570	1.003	0.056	21.61	13.6223	13.5703	0.0519	24.0	4.91E-03	7.15E-03
CYLESS Au	7-12-90	316	3	8.03	1.570	1.002	0.058	21.64	14.1516	14.0523	0.0994	24.0	9.38E-03	
CYLESS Au	7-11-90	410	113	7.70	1.580	1.014	0.060	22.07	14.5840	14.5365	0.0474	24.0	4.58E-03	6.88E-03
CYLESS Au	7-11-90	410	112	7.70	1.545	1.024	0.059	21.78	14.2746	14.1807	0.0939	24.0	9.18E-03	
CYLESS Au	7-18-90	Ag FINAL	6	10.50	1.592	1.004	0.111	23.20	37.0601	36.3276	0.7325	0.5	2.37E+00	2.33E+00
CYLESS Au	7-18-90	Ag FINAL	5	10.50	1.563	0.999	0.109	22.65	36.6290	35.9351	0.6938	0.5	2.30E+00	
CYLESS Au	7-10-90	Ag X	7X	10.50	1.576	1.000	0.123	23.17	39.2964	38.5328	0.7636	0.5	2.47E+00	2.33E+00
CYLESS Au	7-10-90	Ag X	6X	10.50	1.545	1.001	0.124	22.79	38.9415	38.2777	0.6638	0.5	2.18E+00	
CYLESS Au	7-11-90	C4340	75	7.84	1.620	0.996	0.061	22.24	14.6810	14.6345	0.0465	24.0	4.37E-03	2.24E-03
CYLESS Au	7-11-90	C4340	72	7.84	1.570	0.995	0.061	21.56	14.7915	14.7904	0.0011	24.0	1.10E-04	
CYLESS Au	7-12-90	D6AC	68	8.20	1.659	1.008	0.071	23.26	17.5719	17.4176	0.1543	24.0	1.33E-02	8.37E-03
CYLESS Au	7-12-90	D6AC	73	8.20	1.586	1.000	0.076	22.22	18.4270	18.3884	0.0386	24.0	3.48E-03	
CYLESS Au	7-12-90	HA 188	21	9.70	1.572	1.004	0.059	21.73	16.9129	14.3353	2.5776	4.0	1.20E+00	1.10E+00
CYLESS Au	7-12-90	HA 188	18	9.70	1.561	0.999	0.059	21.48	16.8987	14.7958	2.1029	4.0	9.94E-01	
CYLESS Au	7-12-90	I-718	58	8.60	1.598	1.000	0.062	22.06	15.8719	14.3022	1.5697	4.0	8.14E-01	7.08E-01
CYLESS Au	7-12-90	I-718	56	8.60	1.598	1.004	0.062	22.14	16.0773	14.9148	1.1625	4.0	6.01E-01	
140 deg. F	pH-4.5	Current-0.2 Amps												
CYLESS Au	7-20-90	17-4PH	80	7.80	1.553	1.005	0.061	21.54	14.5254	14.5066	0.0188	24.0	1.84E-03	4.54E-03
CYLESS Au	7-20-90	17-4PH	13	7.80	1.496	1.001	0.062	20.72	14.6513	14.5799	0.0714	24.0	7.24E-03	
CYLESS Au	7-20-90	316	1	8.03	1.545	1.008	0.059	21.45	14.2288	14.1194	0.1094	24.0	1.04E-02	1.00E-02
CYLESS Au	7-20-90	316	2	8.03	1.539	1.007	0.058	21.33	14.1092	14.0090	0.1003	24.0	9.60E-03	
CYLESS Au	7-20-90	410	110	7.70	1.555	1.028	0.060	22.02	14.6277	14.5907	0.0370	24.0	3.58E-03	1.53E-03
CYLESS Au	7-20-90	410	109	7.70	1.562	1.038	0.059	22.31	14.5384	14.5438	-0.0055	24.0	-5.22E-04	
CYLESS Au	7-20-90	Ag	10	10.50	1.539	1.002	0.118	22.59	38.9207	38.0703	0.8504	0.5	2.82E+00	3.18E+00
CYLESS Au	7-20-90	Ag	14	10.50	1.568	1.005	0.117	23.03	39.3084	38.2213	1.0871	0.5	3.54E+00	
CYLESS Au	7-23-90	Ag FINAL	10	10.50	1.539	0.998	0.119	22.53	38.0703	37.0461	1.0242	0.5	3.41E+00	3.42E+00

Stripper	Test Date	Coupon Material	Coupon #	Density (g/cm3)	Unwaxed Dimensions in inches length	width	thick	Surface Area (cm2)	Initial Mass (grams)	Final Mass (grams)	Change Mass (grams)	Total Time (hours)	Stripping Rate (mil/hr)	Average S.R. (mil/hr)
CYLESS Au	7-23-90	Ag FINAL	14	10.50	1.568	1.005	0.118	23.06	38.2213	37.1653	1.0560	0.5	3.43E+00	
CYLESS Au	7-20-90	C4340	77	7.84	1.534	1.016	0.061	21.51	15.0020	14.9546	0.0474	24.0	4.61E-03	4.08E-03
CYLESS Au	7-20-90	C4340	76	7.84	1.546	0.996	0.062	21.28	14.7860	14.7498	0.0362	24.0	3.56E-03	
CYLESS Au	7-20-90	D6AC	74	8.20	1.545	1.001	0.077	21.72	18.2670	18.2289	0.0381	24.0	3.51E-03	3.26E-03
CYLESS Au	7-20-90	D6AC	88	8.20	1.531	1.010	0.084	21.88	20.2066	20.1738	0.0329	24.0	3.01E-03	
CYLESS Au	7-23-90	HA 188	89	9.70	1.438	1.002	0.127	21.41	35.8526	34.7088	1.1438	2.0	1.08E+00	1.12E+00
CYLESS Au	7-23-90	HA 188	22	9.70	1.460	1.001	0.060	20.20	16.8497	15.6974	1.1523	2.0	1.16E+00	
CYLESS Au	7-23-90	I-718	52	8.60	1.586	1.004	0.062	21.98	15.9591	15.2153	0.7438	2.0	7.74E-01	6.79E-01
CYLESS Au	7-23-90	I-718	61	8.60	1.498	1.004	0.062	20.81	15.8527	15.3225	0.5302	2.0	5.83E-01	
90 deg. F pH-4.5 Current-0.2 Amps Longevity Test														
CYLESS Au	7-10-90	Ag	6	10.50	1.650	1.005	0.116	24.1358	38.1674	37.0864	1.0811	0.5	3.36E+00	3.29E+00
CYLESS Au	7-10-90	Ag	5	10.50	1.550	1.002	0.117	22.7227	37.6383	36.6593	0.9790	0.5	3.23E+00	
CYLESS Au	7-10-90	HA 188	41	9.70	1.543	1.006	0.060	21.4052	17.1994	15.4211	1.7784	2.0	1.69E+00	
CYLESS Au	7-10-90	I-718	55	8.60	1.570	0.999	0.063	21.6880	16.0120	15.7750	0.2370	2.0	2.50E-01	

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APPENDIX L

GRAPHICAL PRESENTATION OF THE NICKEL STRIPPER FIELD-TEST DATA FROM PHASES II & III

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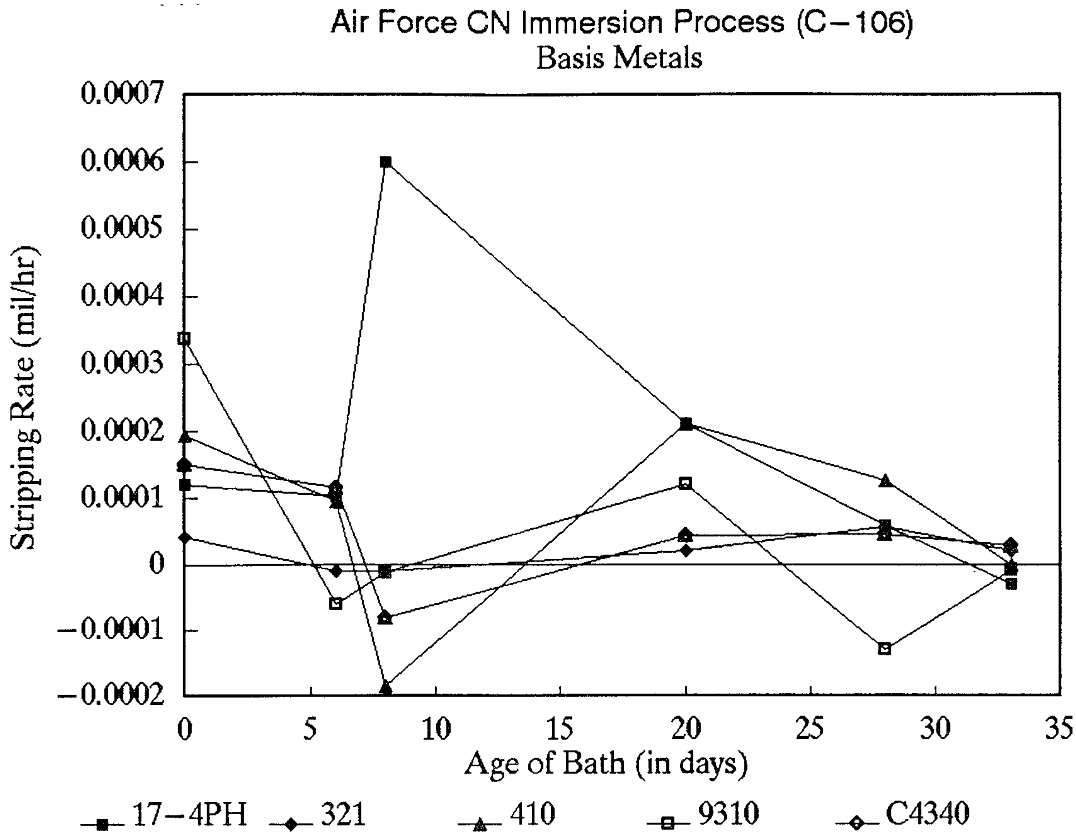
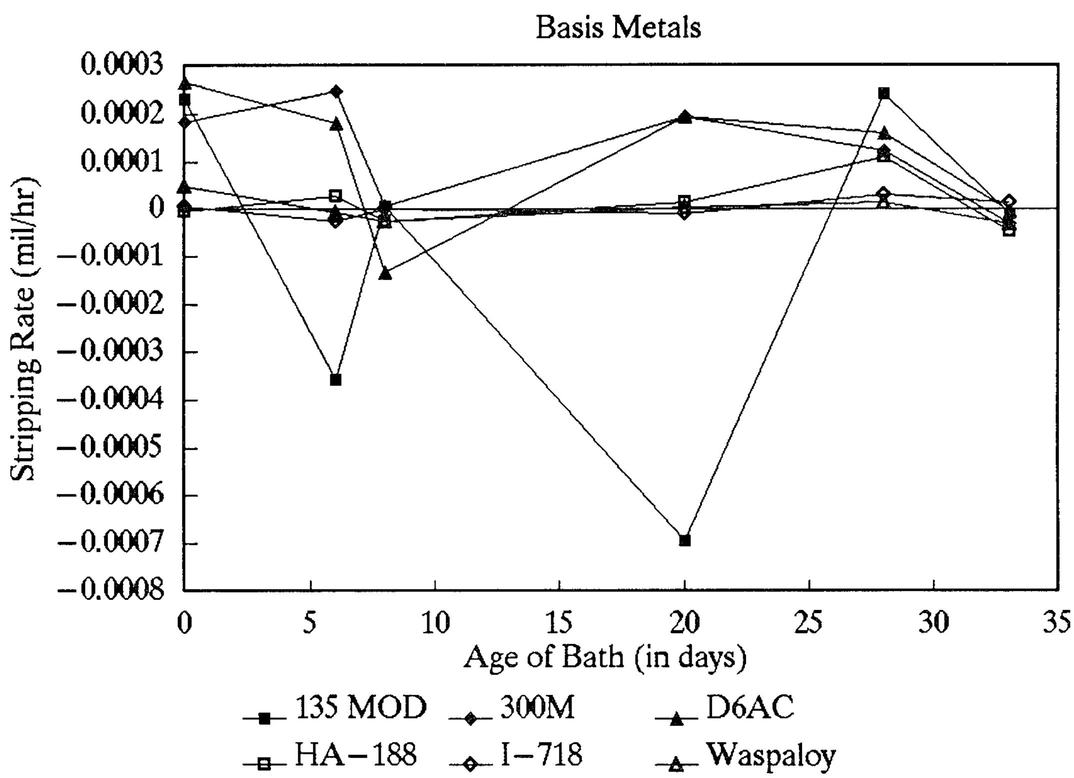
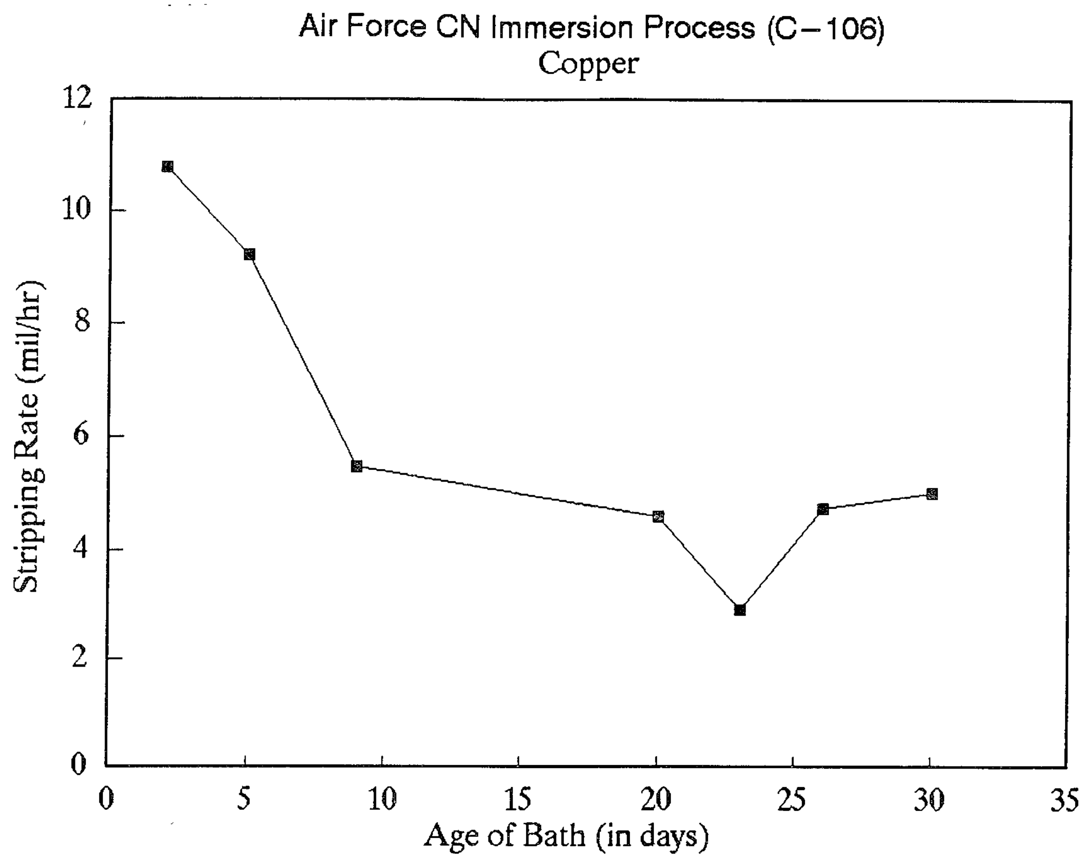
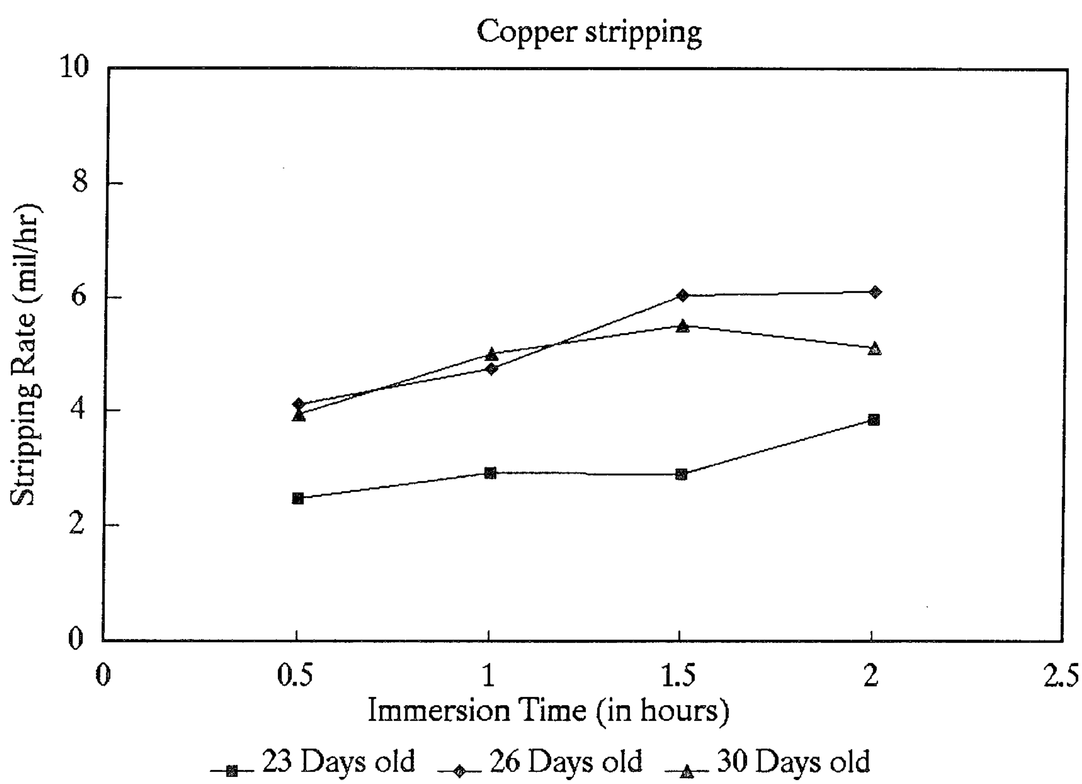
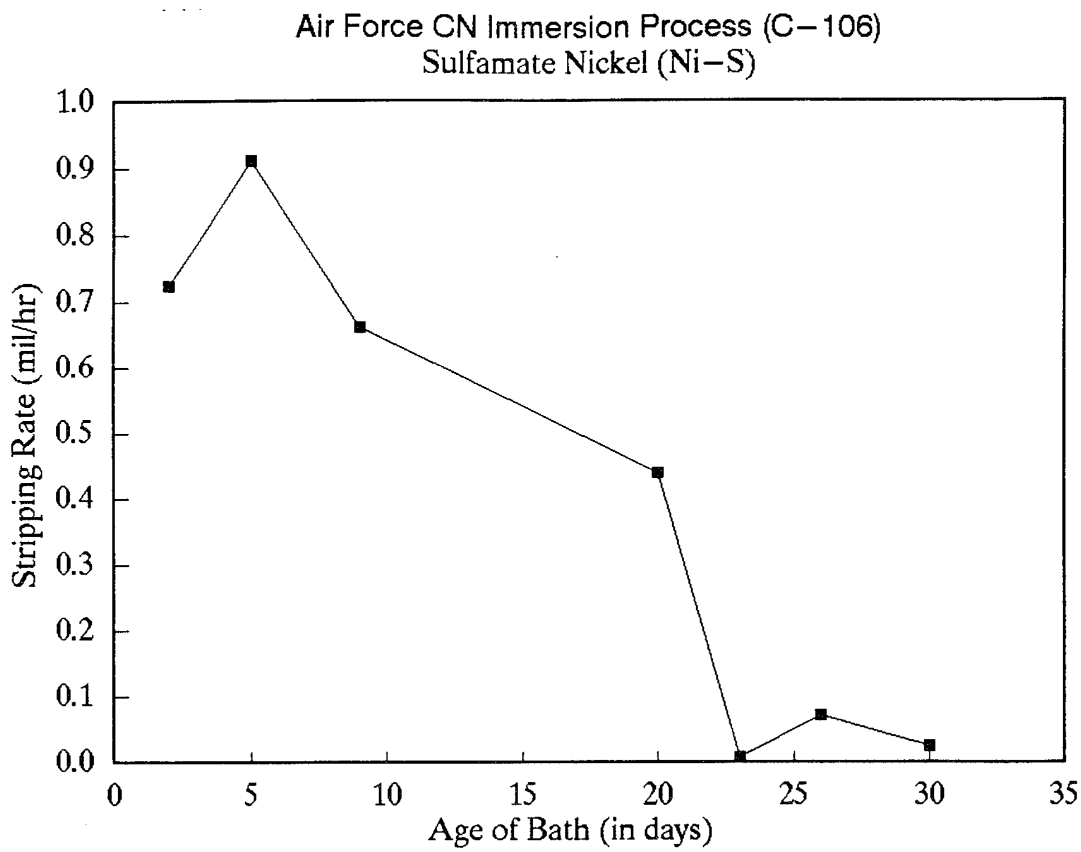
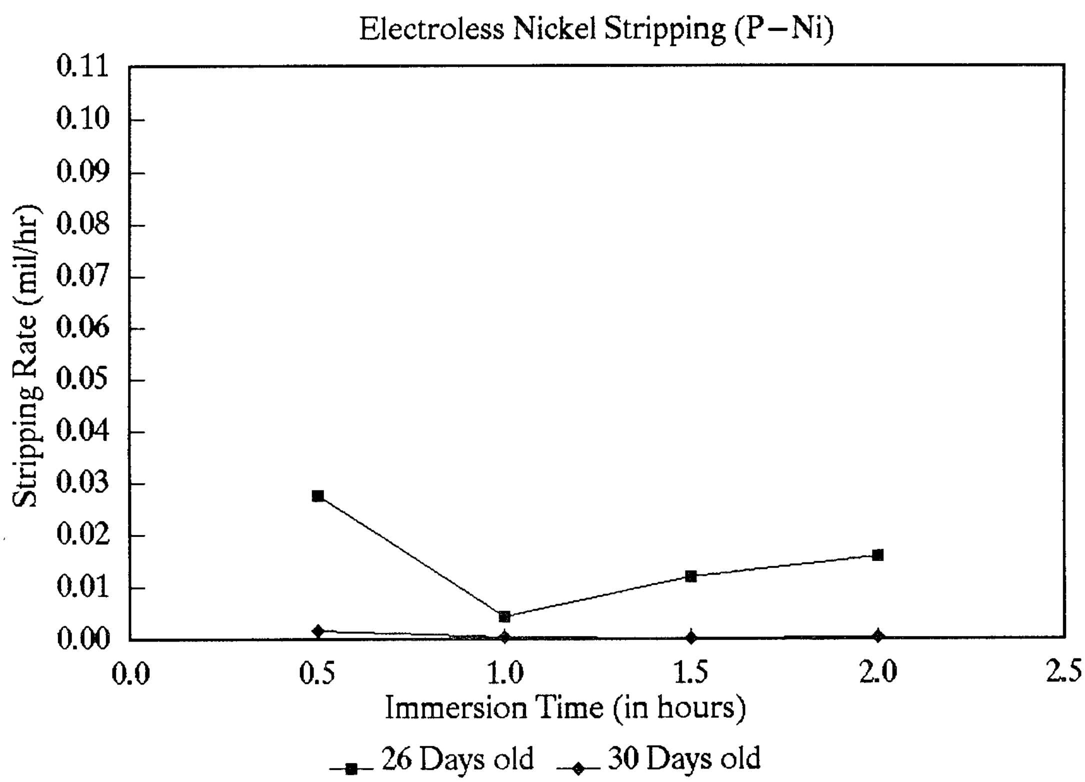

Air Force CN Immersion Process (C−106)
Basis Metals
Stripping Rate (mil/hr)
0.0007
0.0006
0.0005
0.0004
0.0003
0.0002
0.0001
0
−0.0001
−0.0002
0
5
10
15
20
25
30
35
Age of Bath (in days)
17−4PH
321
410
9310
C4340


Basis Metals
Stripping Rate (mil/hr)
0.0003
0.0002
0.0001
0
−0.0001
−0.0002
−0.0003
−0.0004
−0.0005
−0.0006
−0.0007
−0.0008
0
5
10
15
20
25
30
35
Age of Bath (in days)
135 MOD
300M
D6AC
HA−188
I−718
Waspaloy

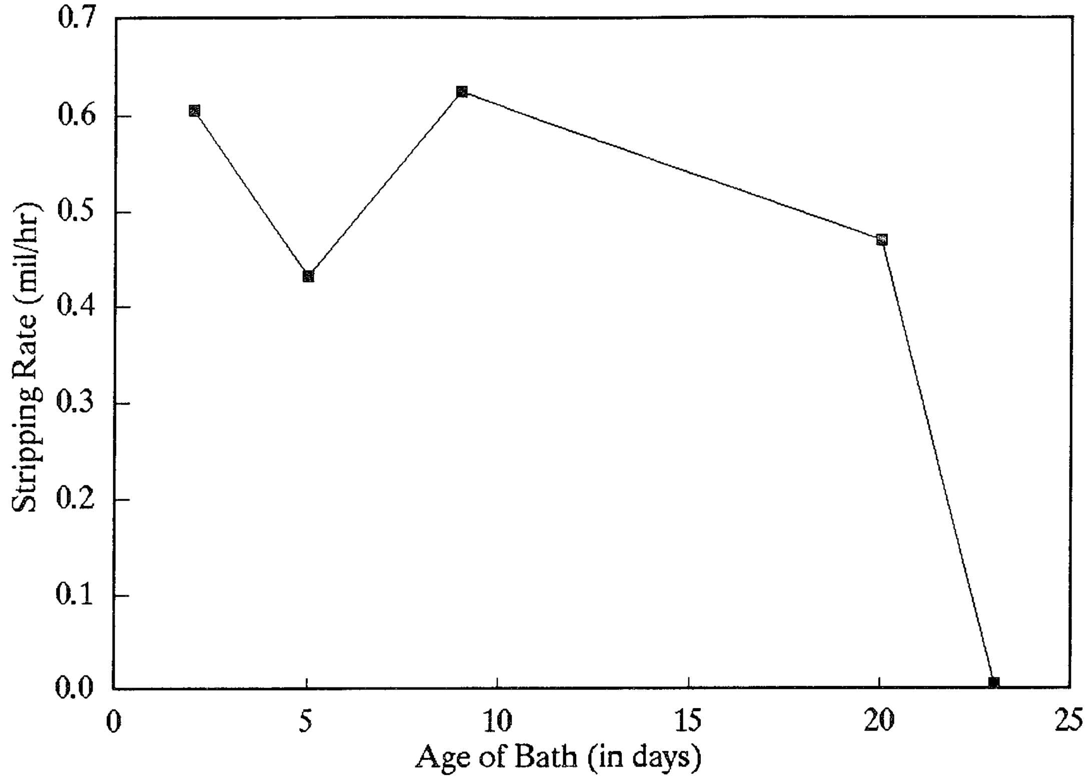

Air Force CN Immersion Process (C−106)
Copper
Stripping Rate (mil/hr)
Age of Bath (in days)
0
2
4
6
8
10
12
0
5
10
15
20
25
30
35


Copper stripping
Stripping Rate (mil/hr)
Immersion Time (in hours)
0
2
4
6
8
10
0
0.5
1
1.5
2
2.5
23 Days old
26 Days old
30 Days old

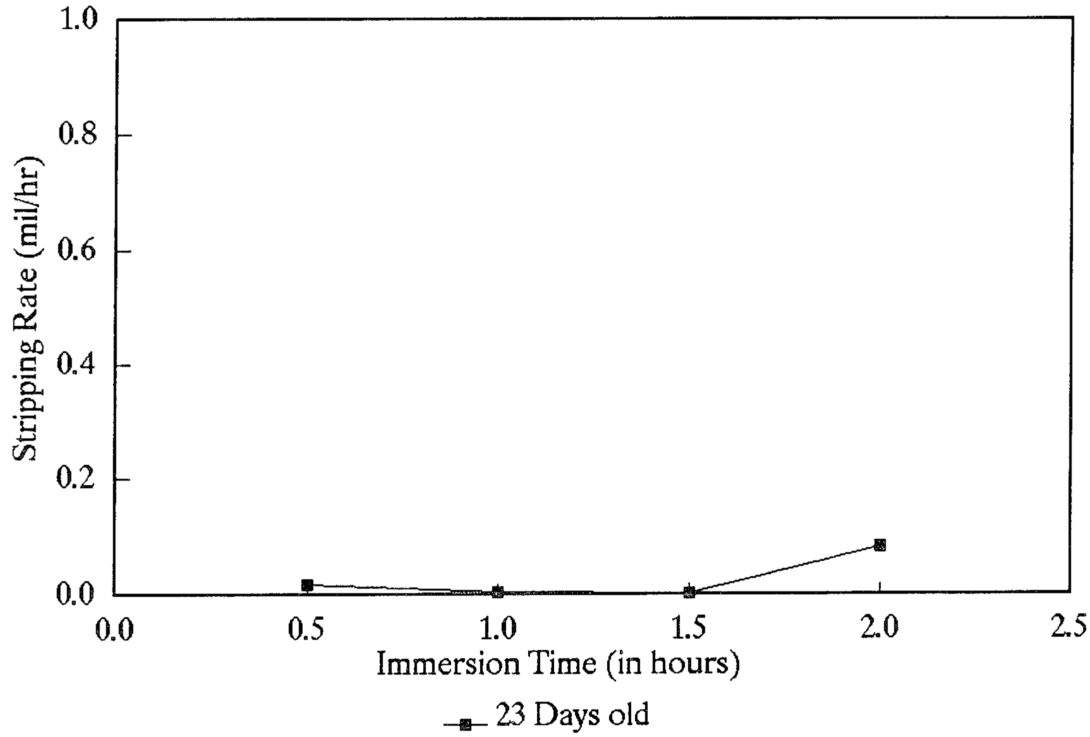

Air Force CN Immersion Process (C−106)
Sulfamate Nickel (Ni−S)
Stripping Rate (mil/hr)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
5
10
15
20
25
30
35
Age of Bath (in days)


Electroless Nickel Stripping (P−Ni)
Stripping Rate (mil/hr)
0.11
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
0.0
0.5
1.0
1.5
2.0
2.5
Immersion Time (in hours)
26 Days old
30 Days old

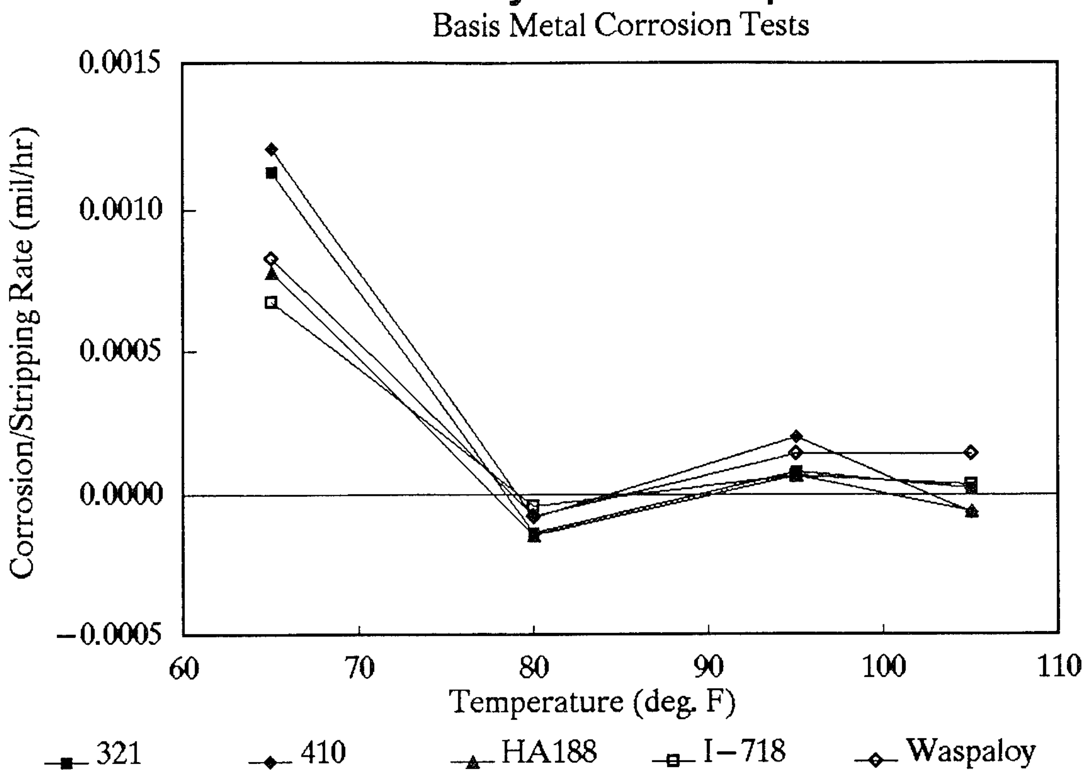
Air Force CN Immersion Process (C-106)
Pure Nickel (N-100)

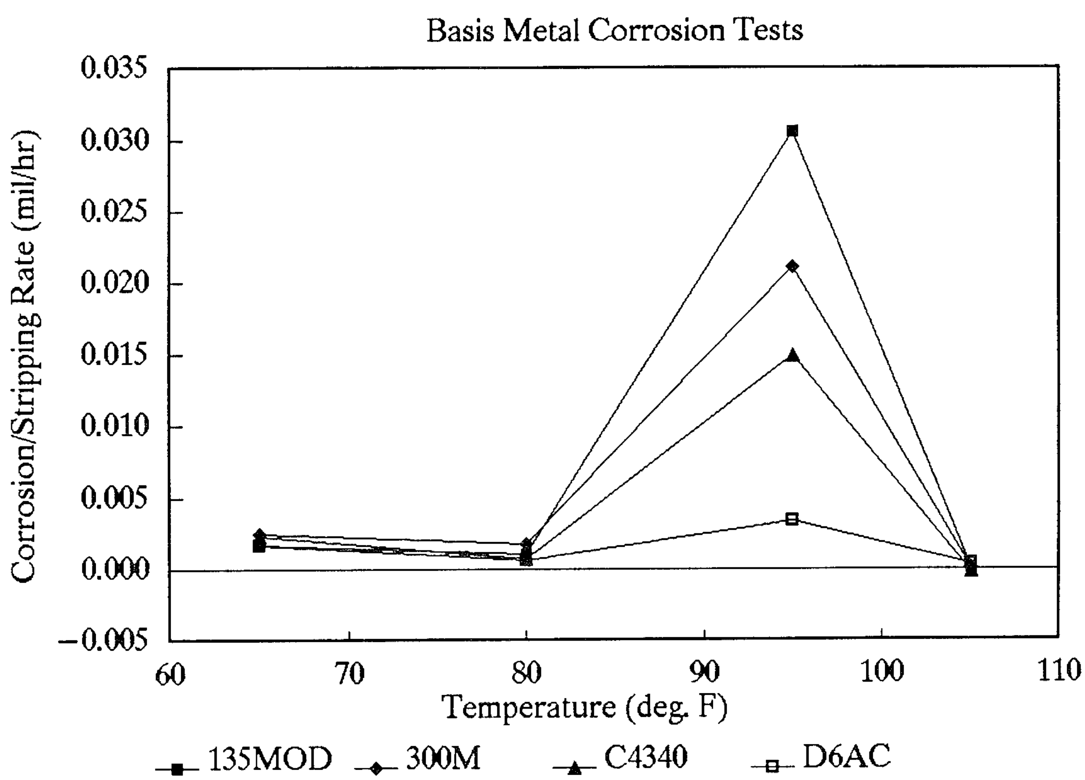


Pure Nickel (N-100)

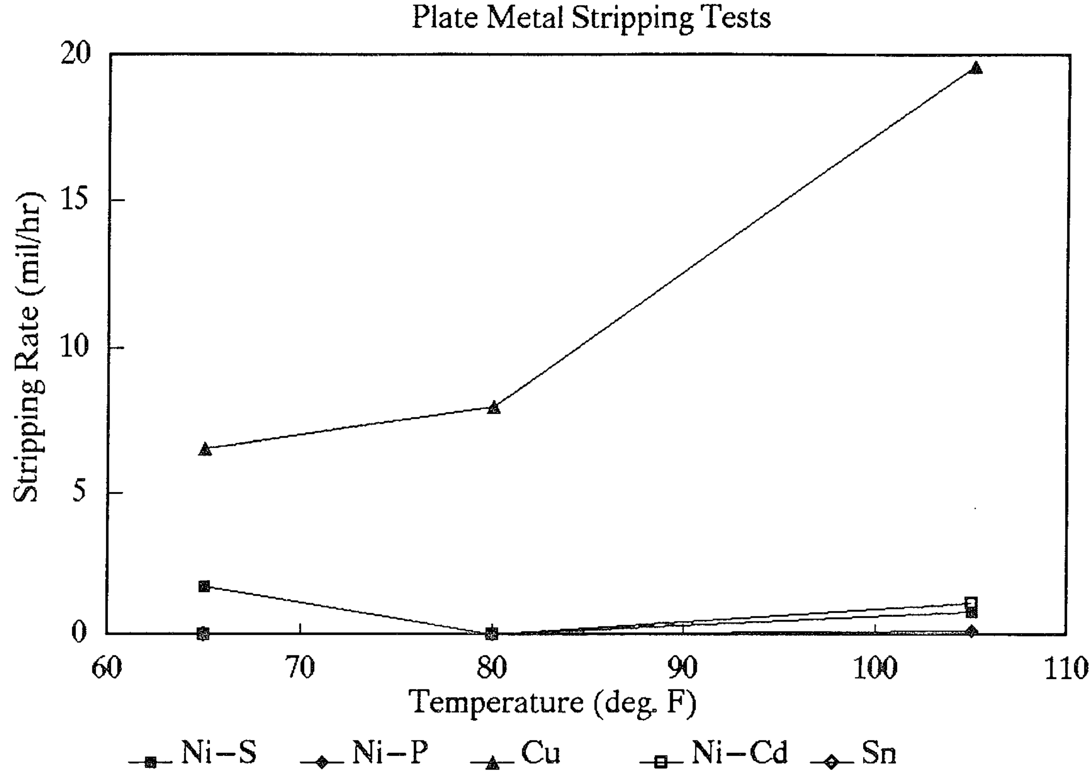


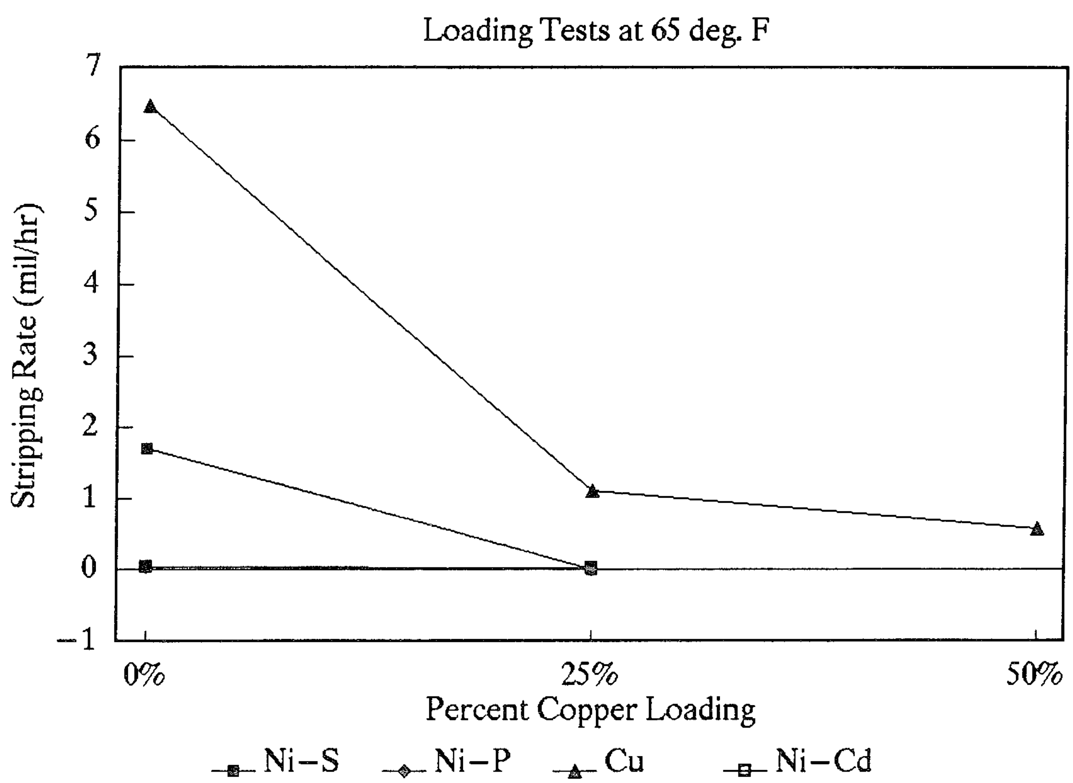
Circuit Chemistry's Cirstrip NCN–Cu



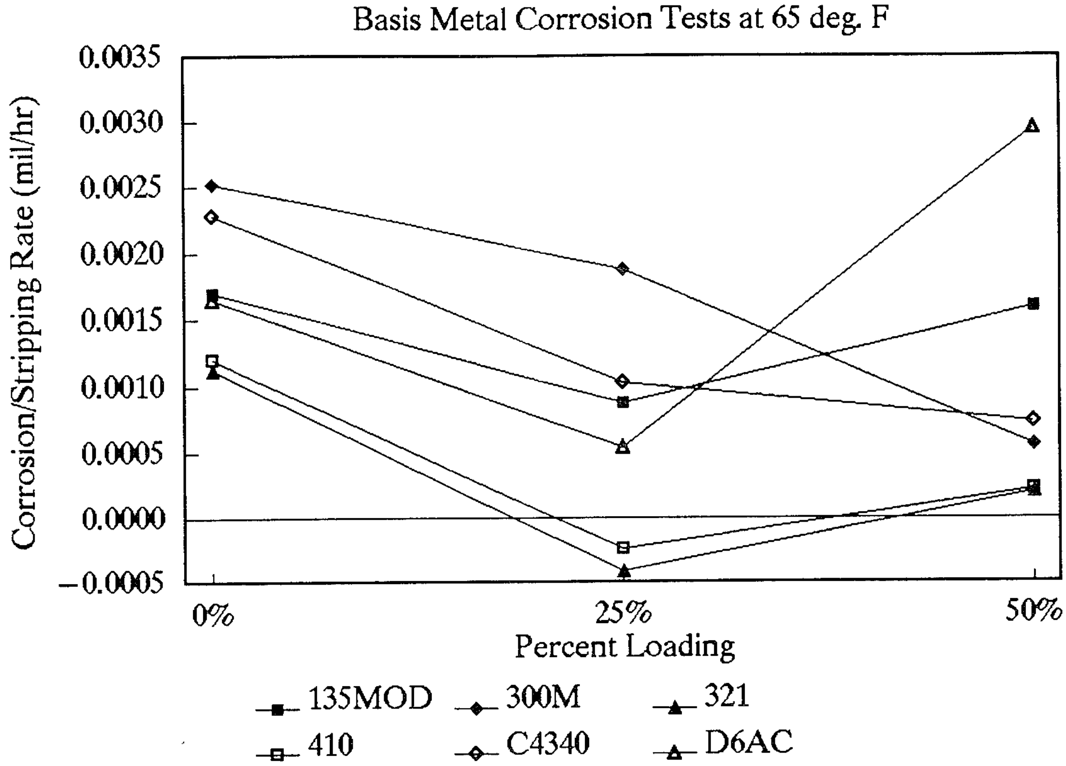


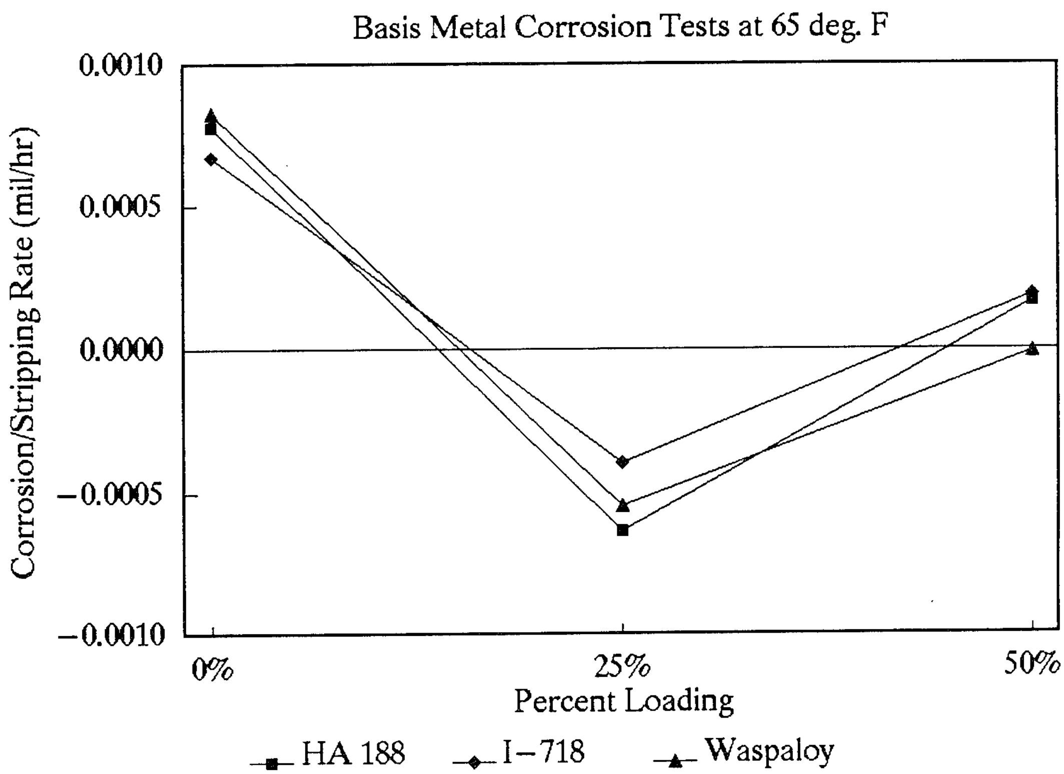
Circuit Chemistry's Cirstrip NCN−Cu





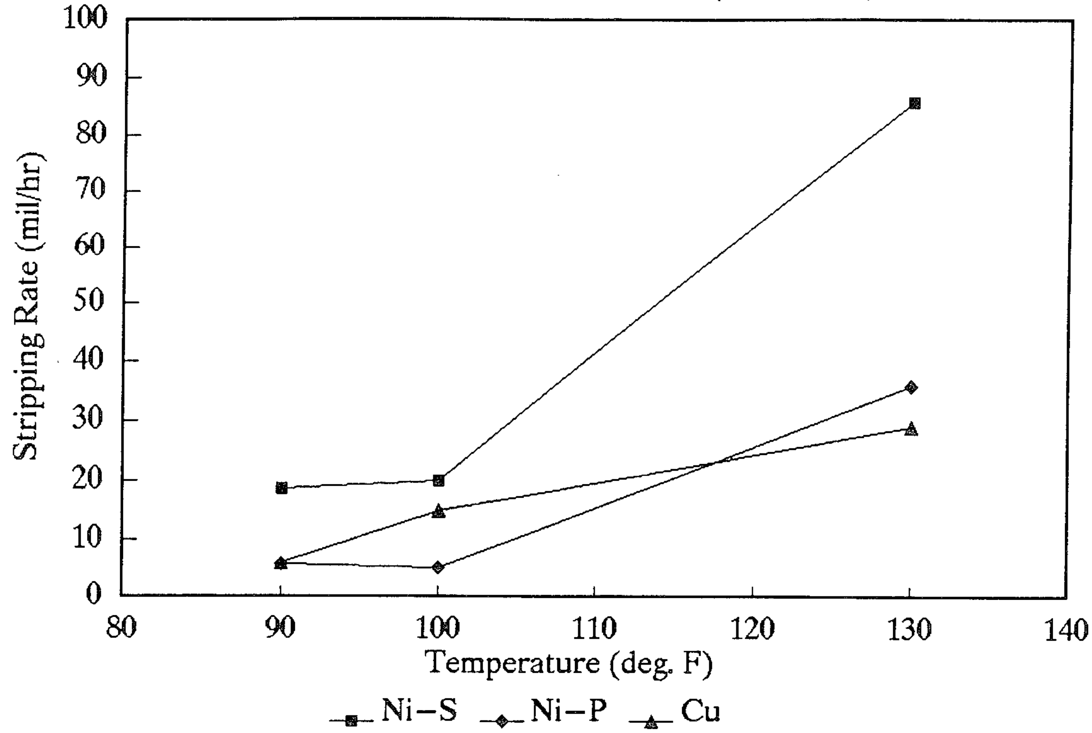
Circuit Chemistry's Cirstrip NCN−Cu





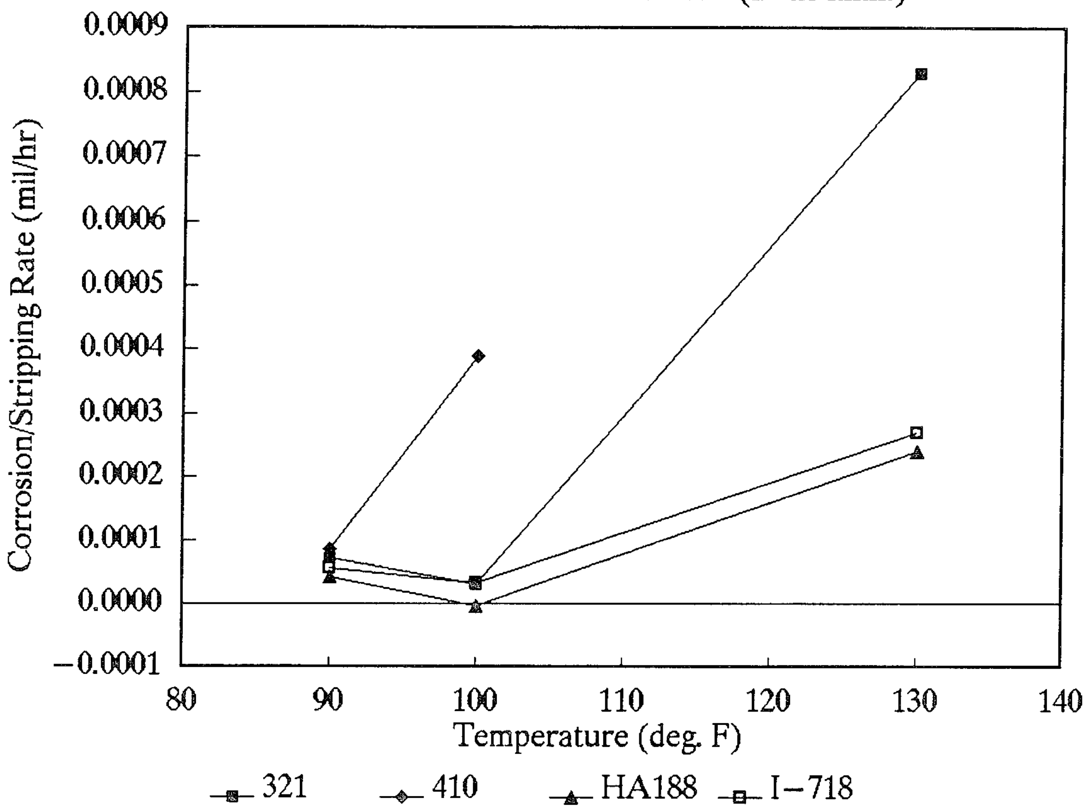
Electrochemicals' Nickel–Sol Process ***

Plate Metal Corrosion Tests (24 hr Imm.)



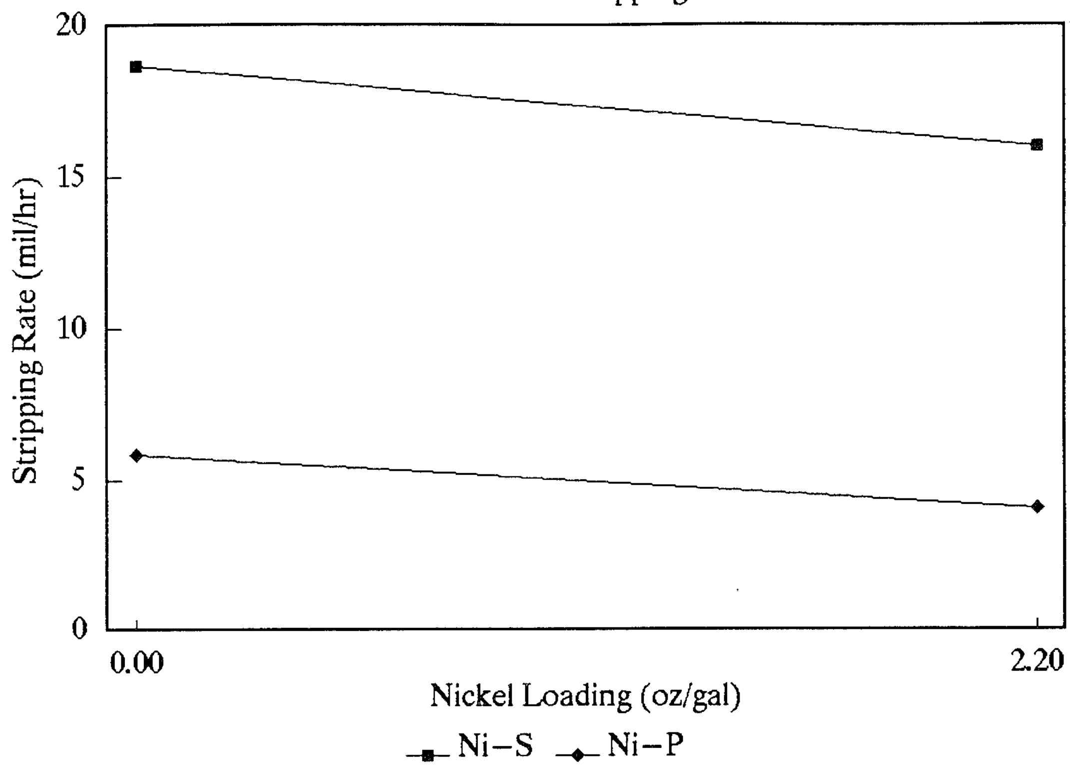
*** Note that the scale is greatly expanded

Basis Metal Corrosion Tests (24 hr Imm.)

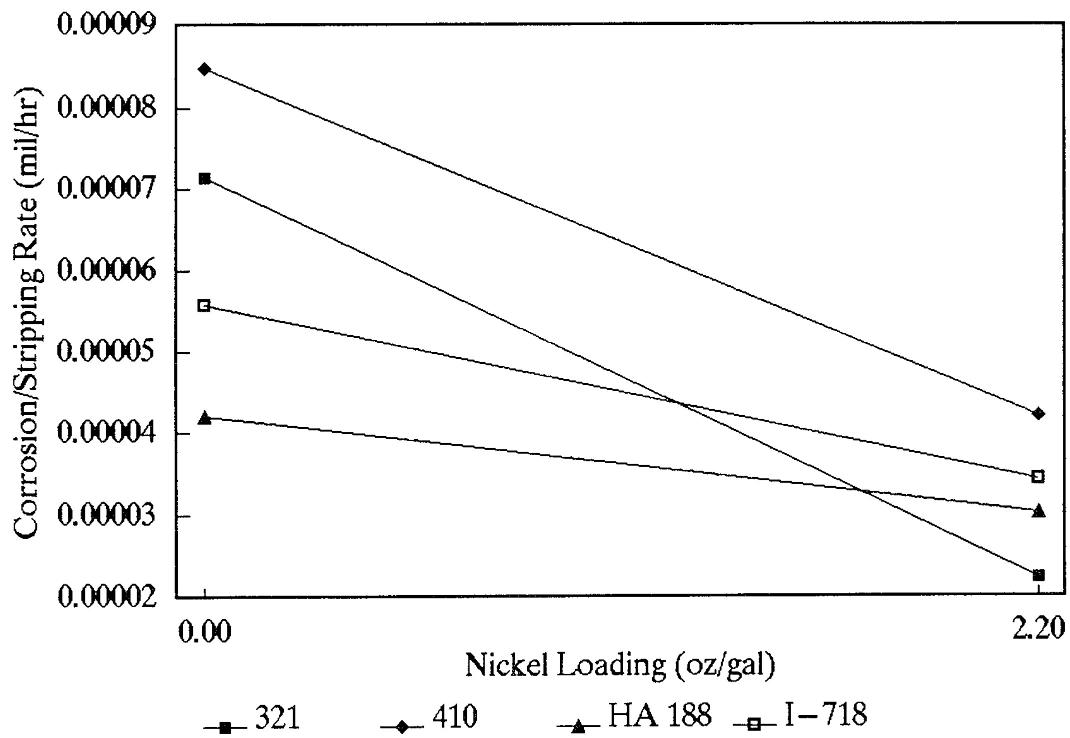


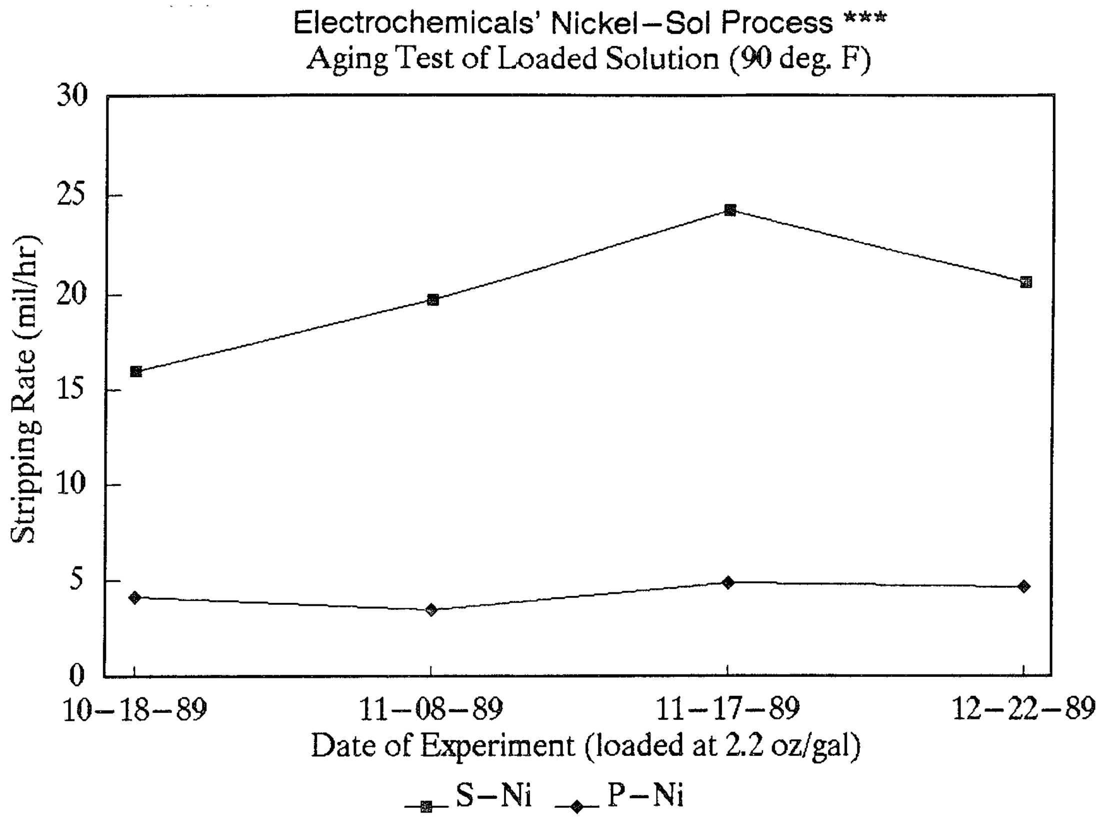
Electrochemicals' Nickel–Sol Process

Plate Metal Stripping Tests



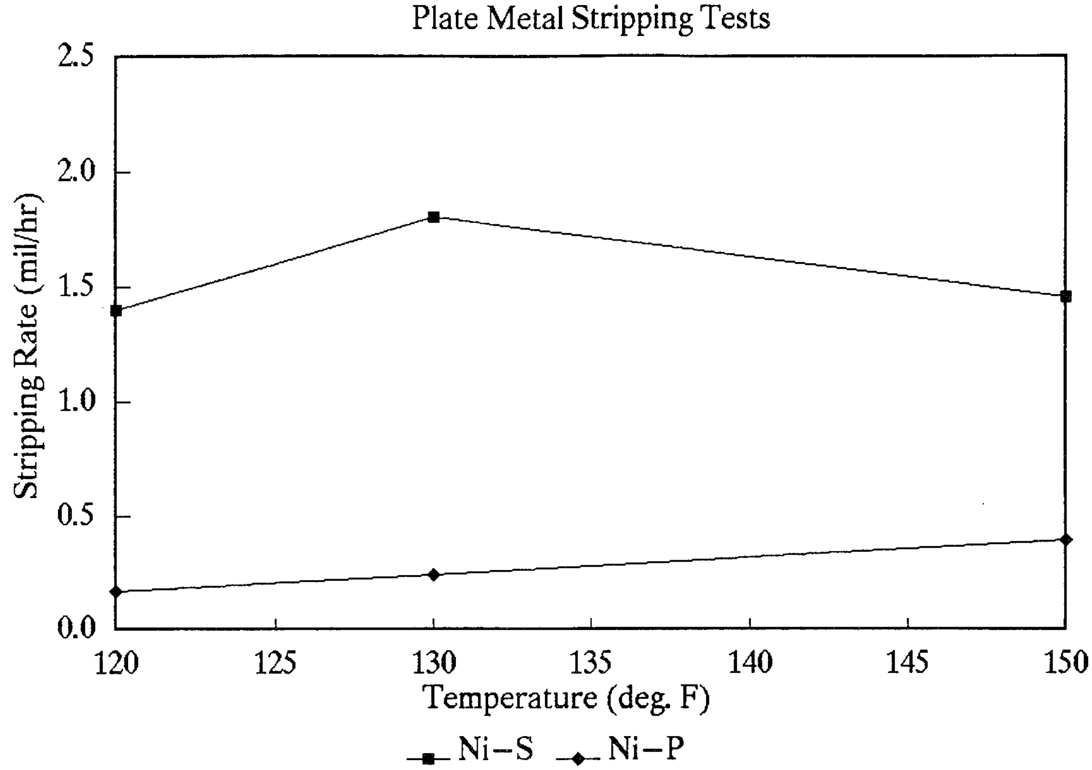
Basis Metal Corrosion Tests

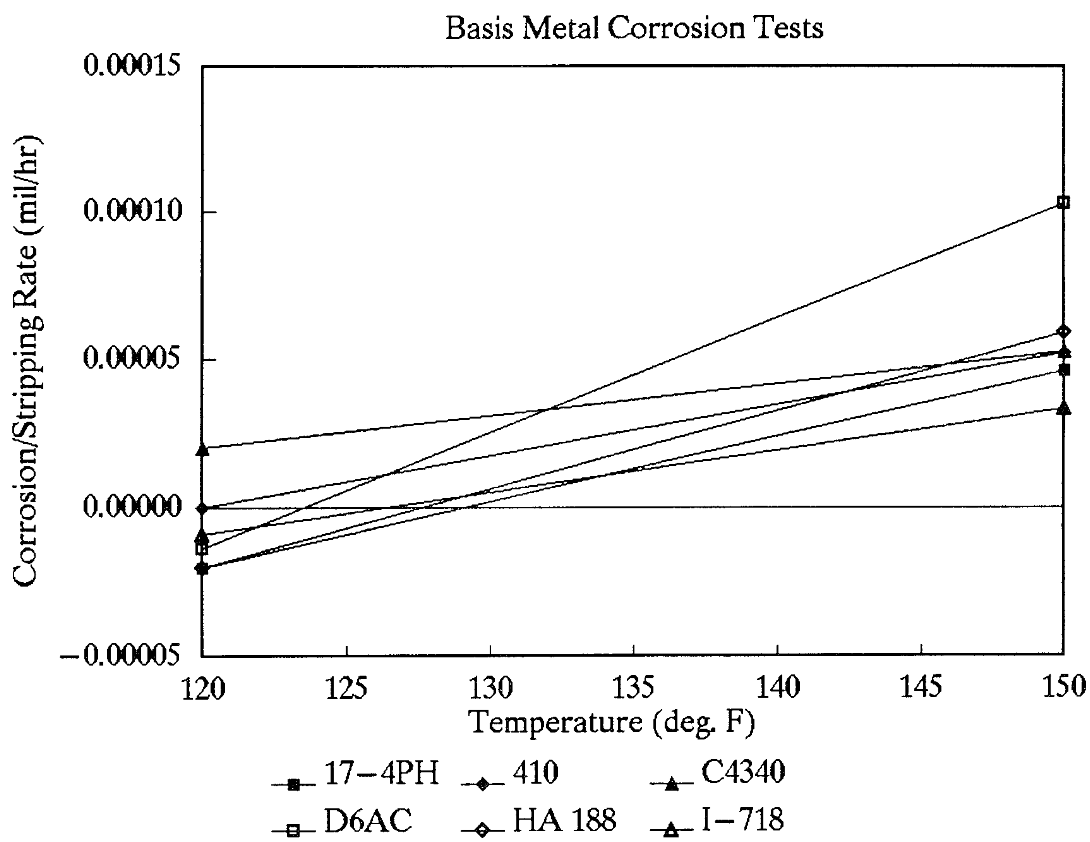




*** Note that the scale is expanded

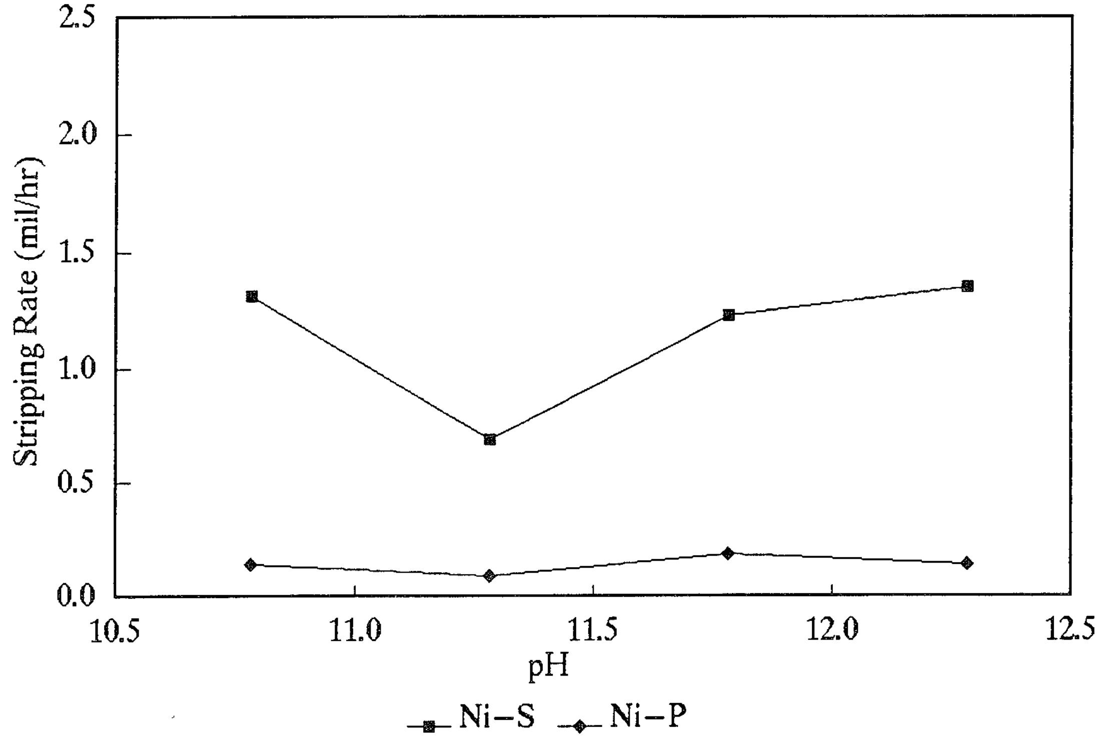
Enthone's Enstrip N−190



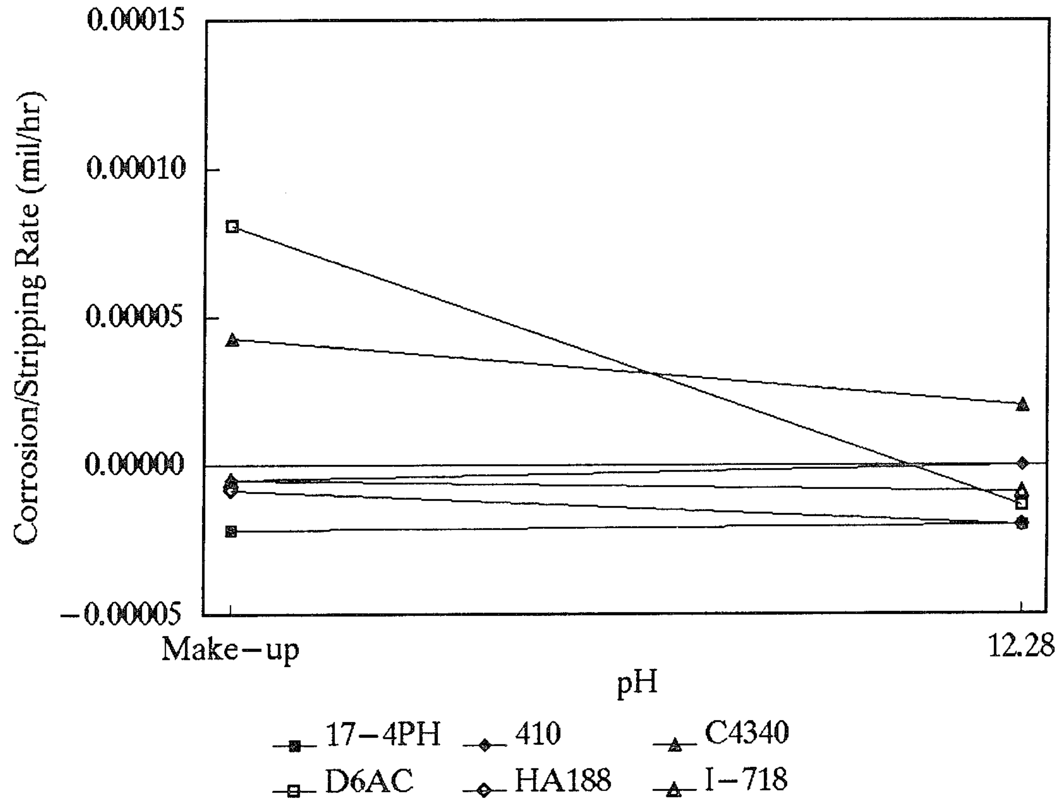


Enthone's Enstrip N-190

Plate Metal Stripping Tests at 120 deg. F

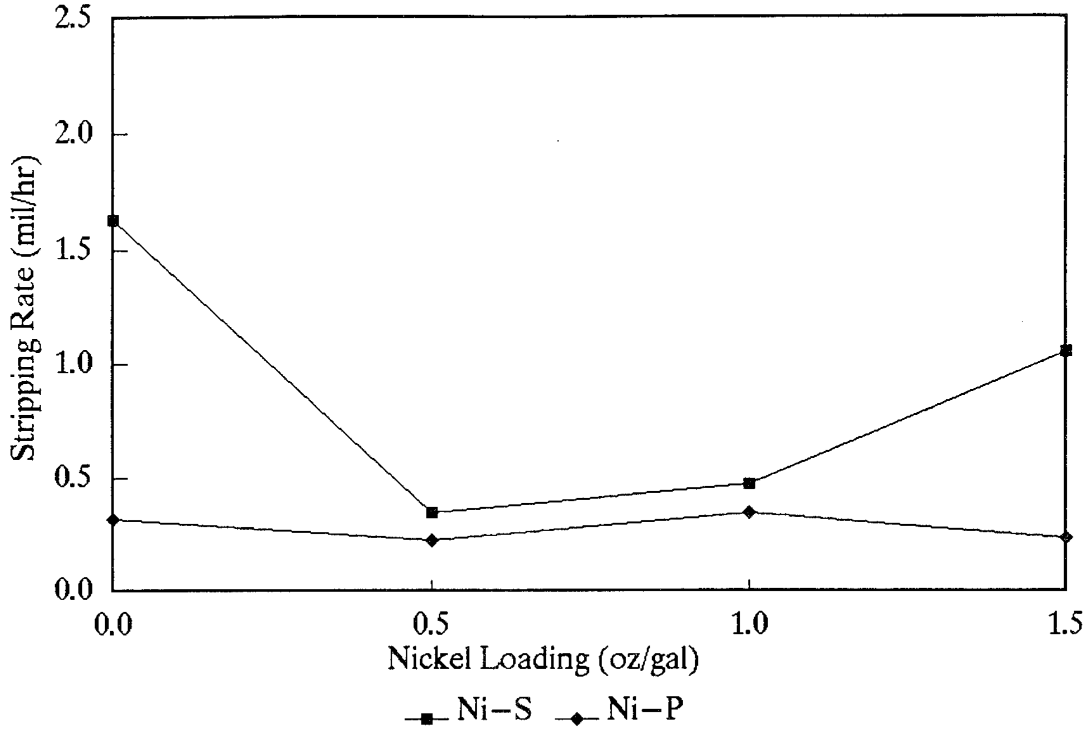


Basis Metal Corrosion Tests at 120 deg. F

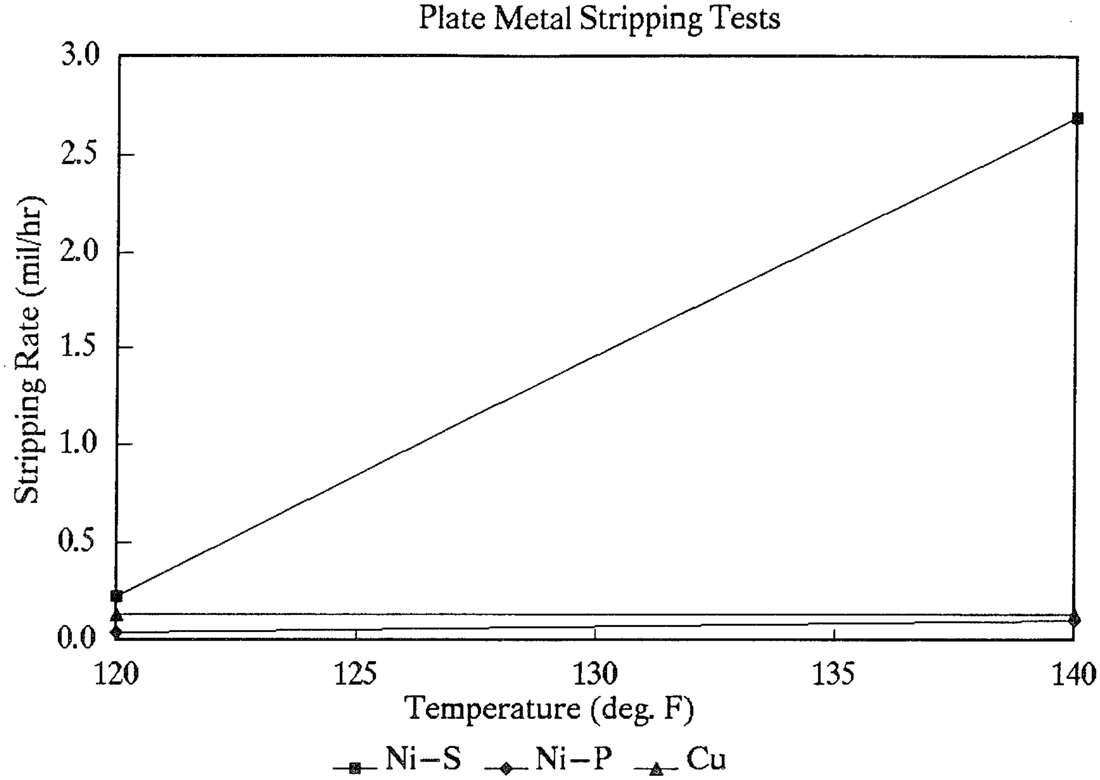


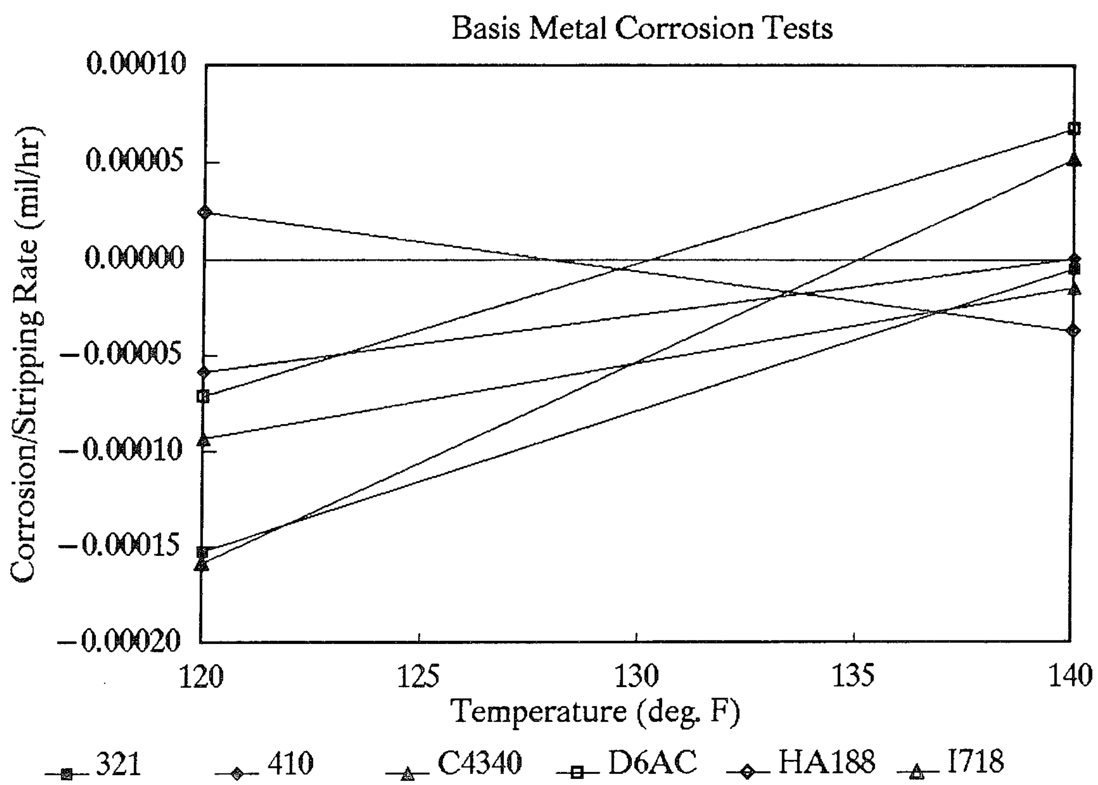
Enthone's Enstrip N–190

Plate Metal Stripping Tests

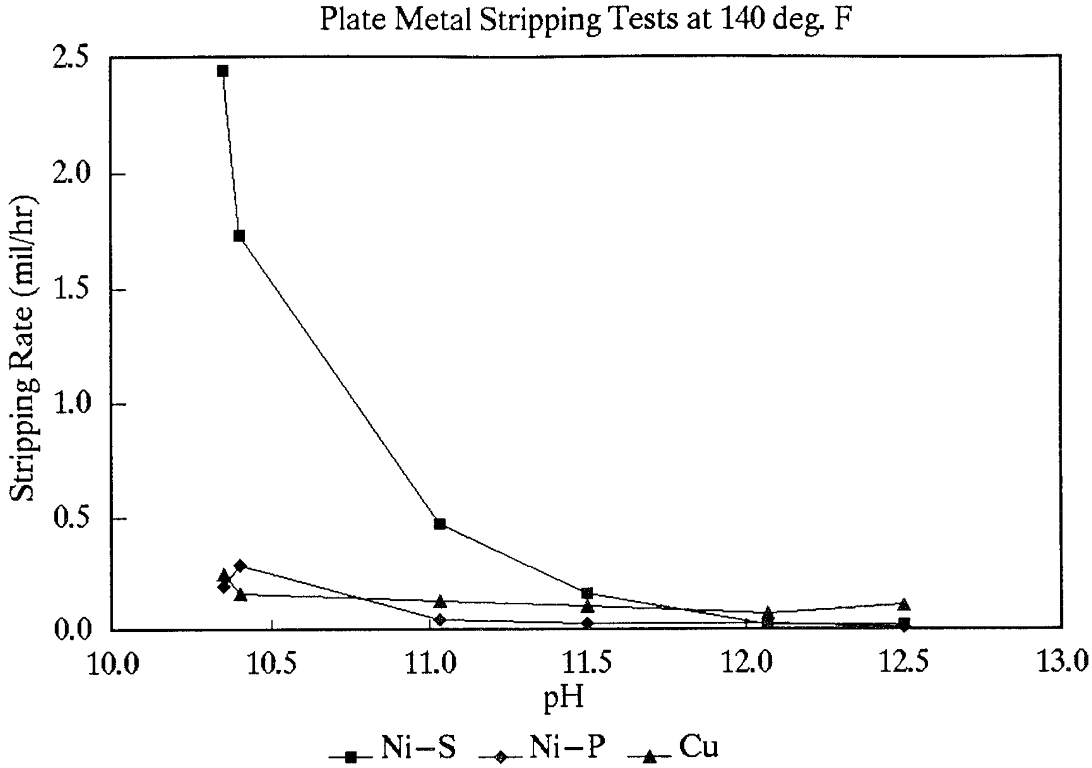


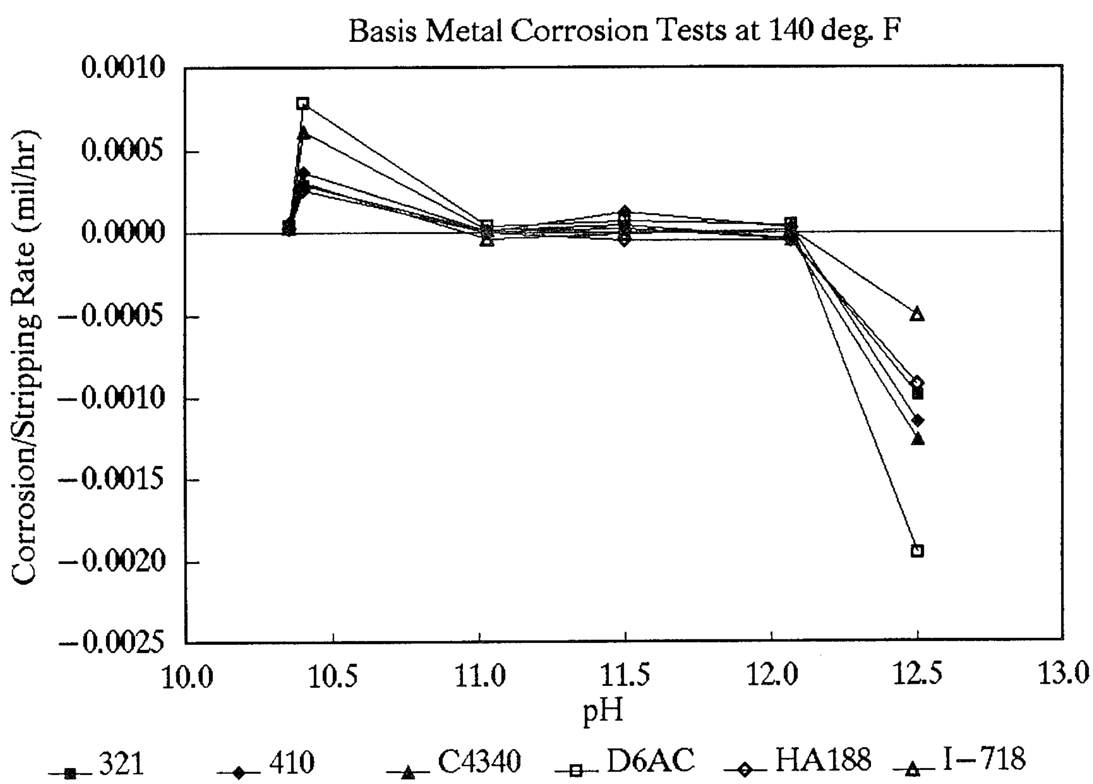
Frederick Gumm's CLEPO 204



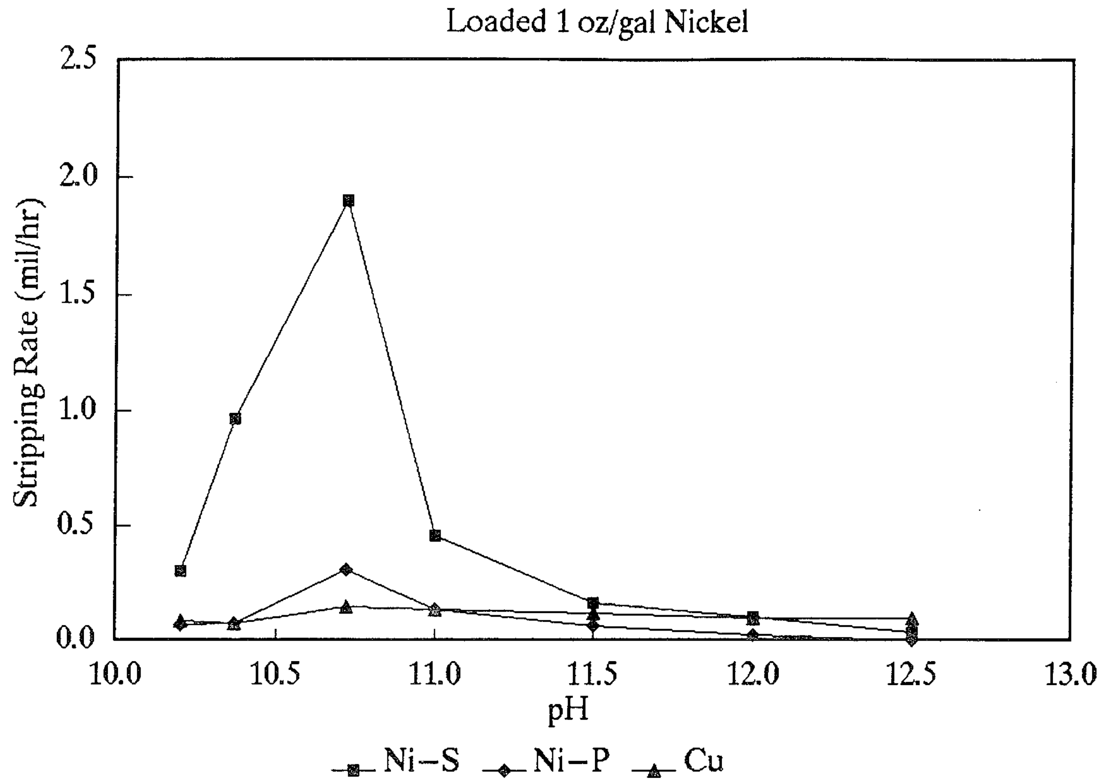


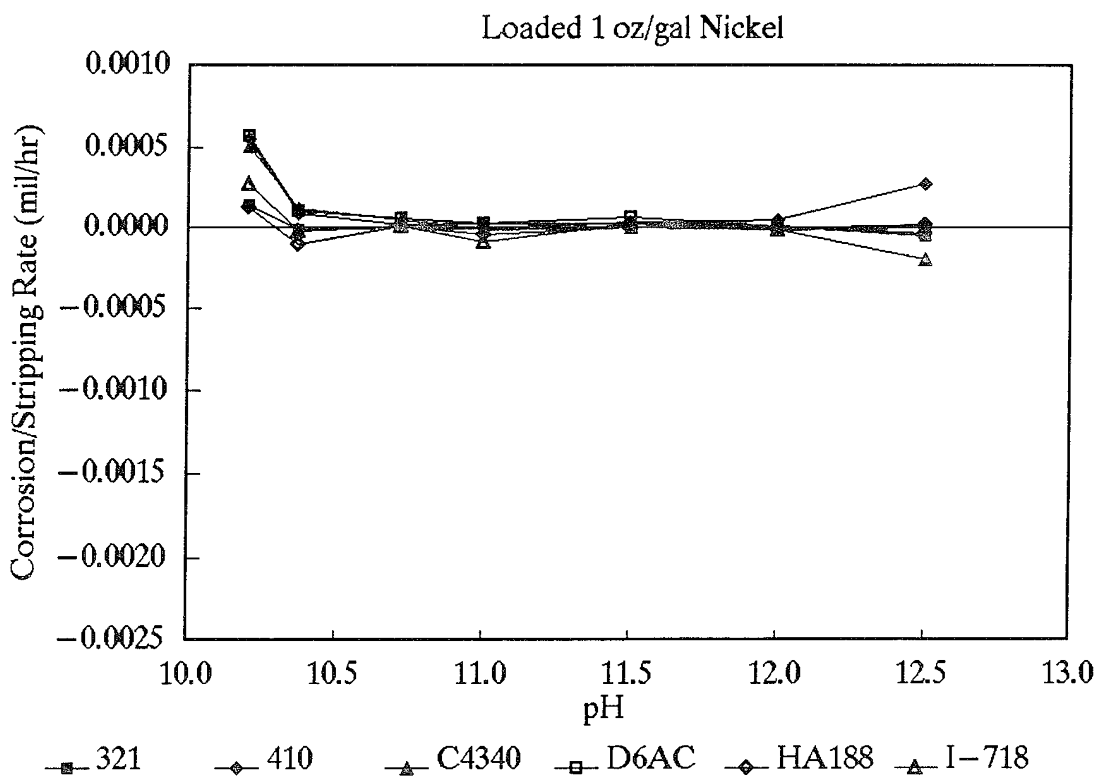
Frederick Gumm's CLEPO 204



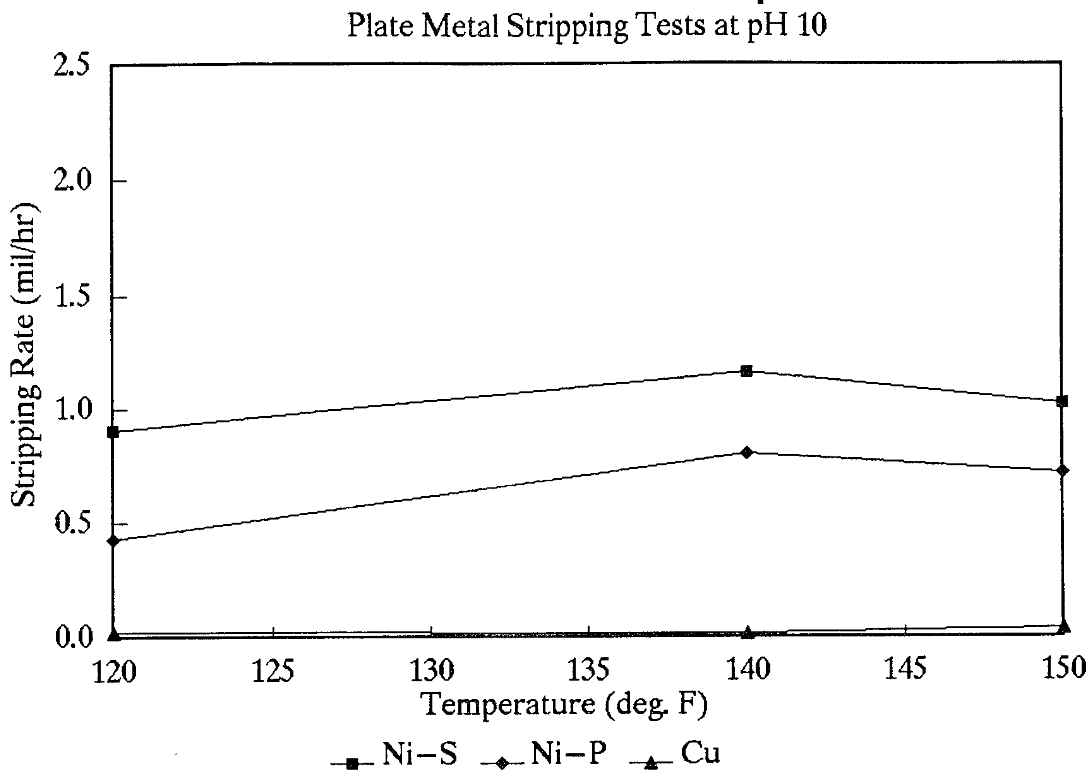


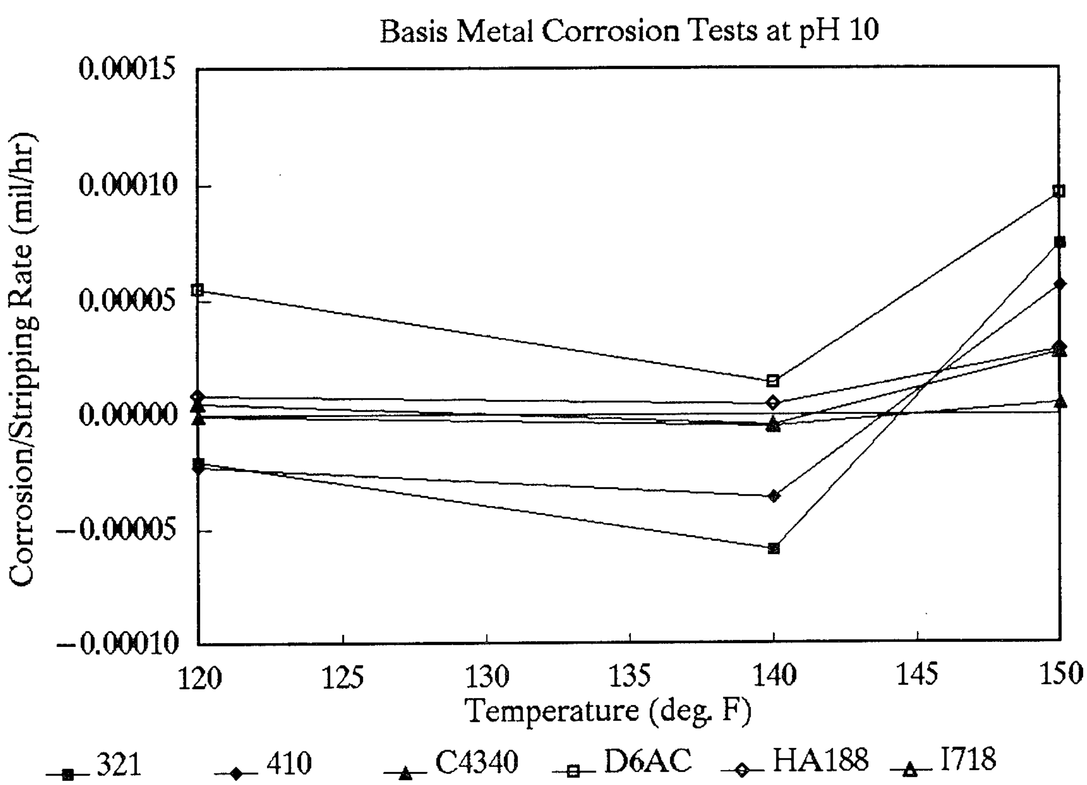
Frederick Gumm's CLEPO 204



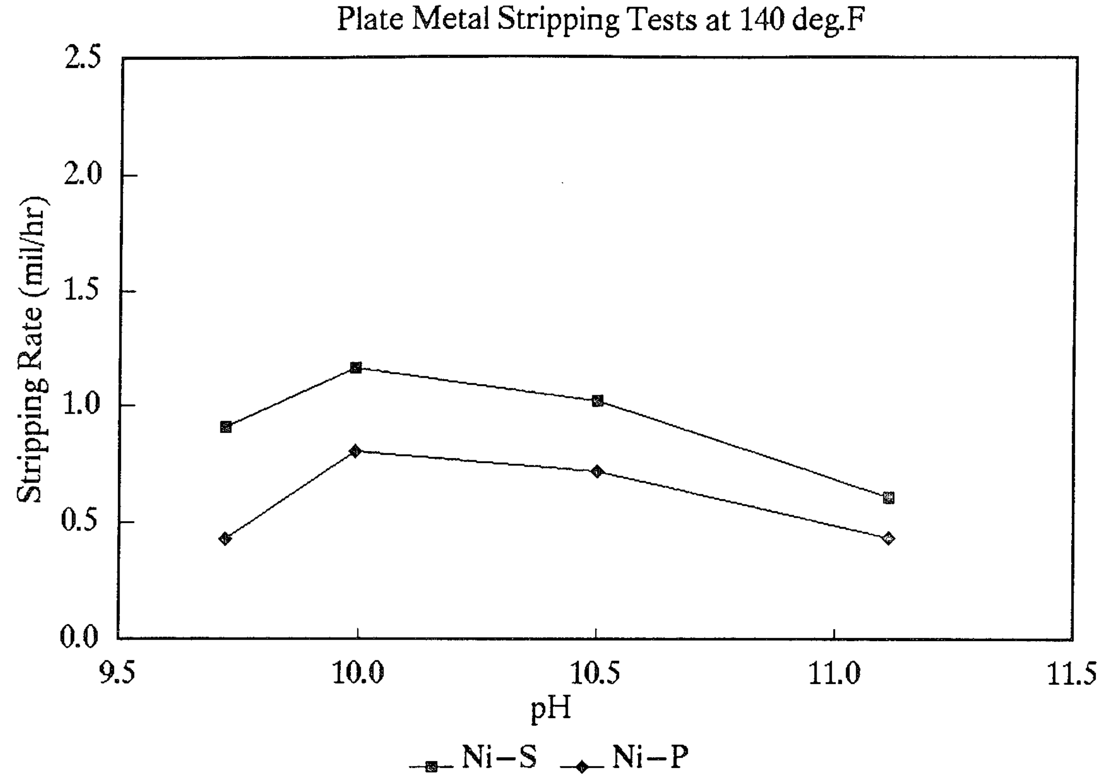


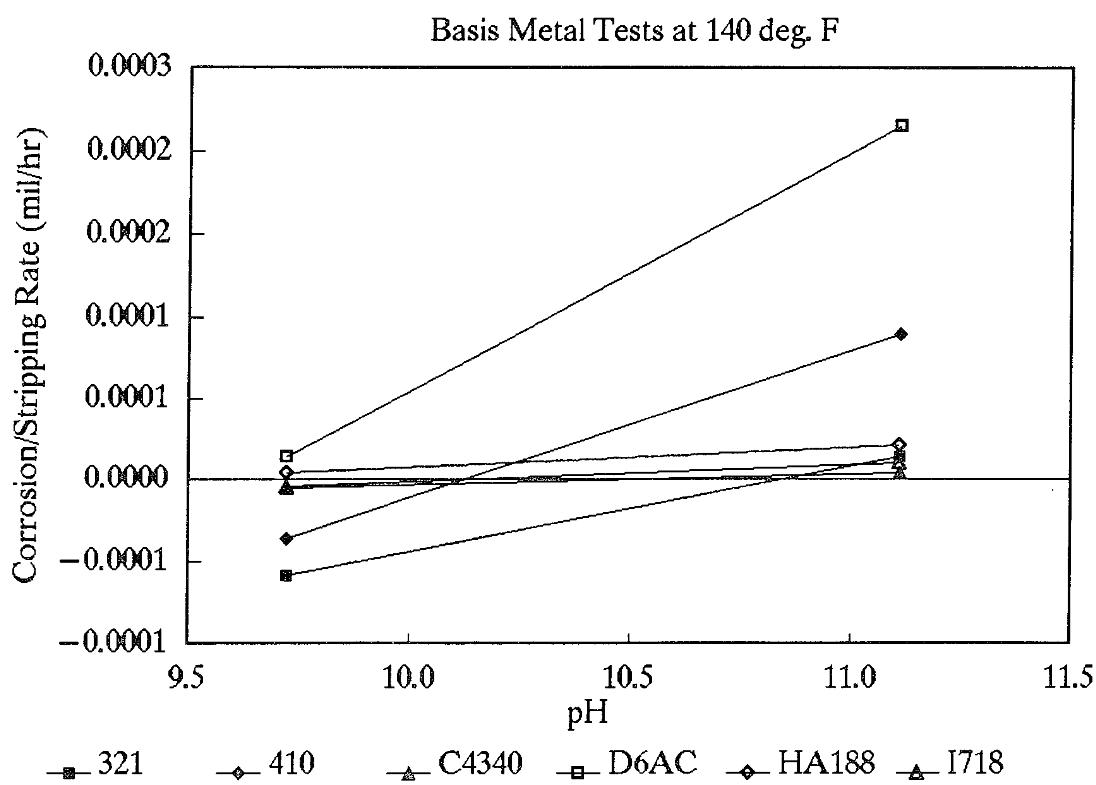
M&T Harshaw's Ni-plex 100



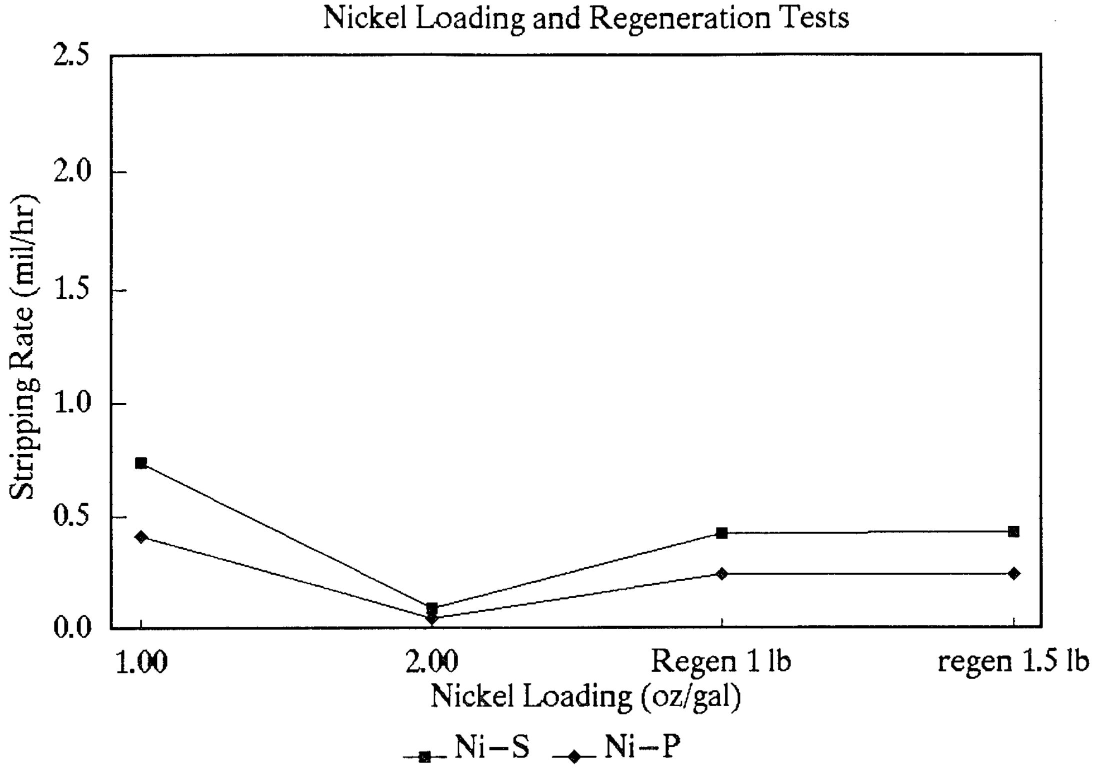


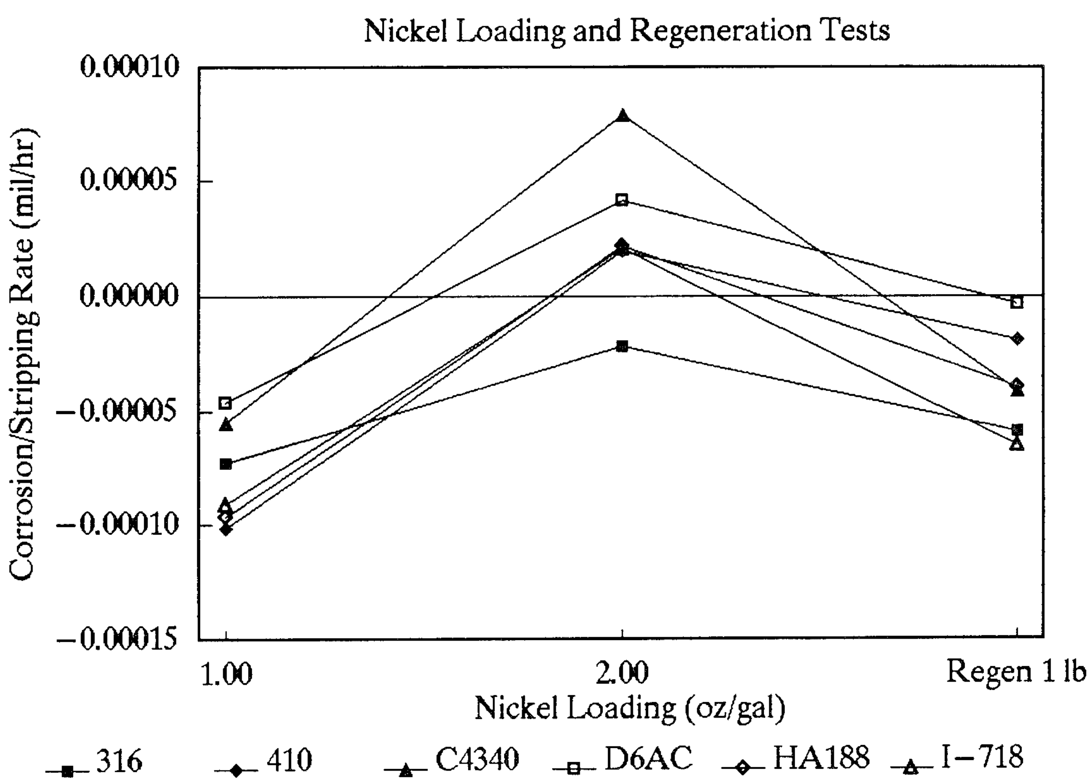
M&T Harshaw's Ni–plex 100





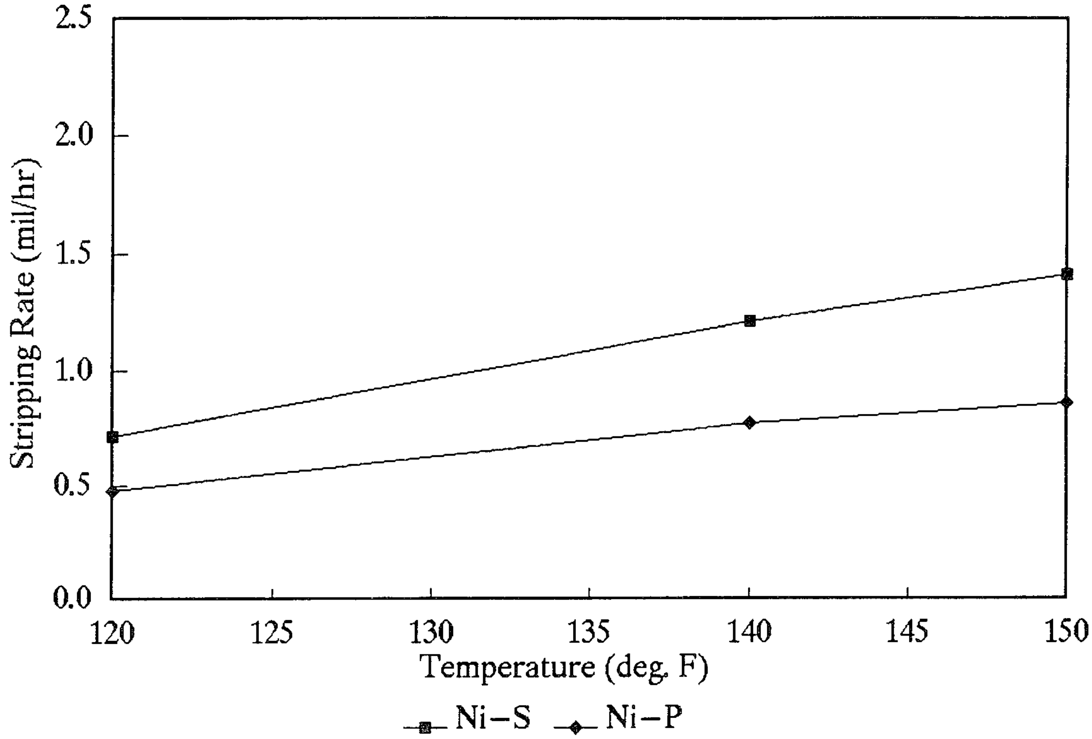
M&T Harshaw's Ni–plex 100



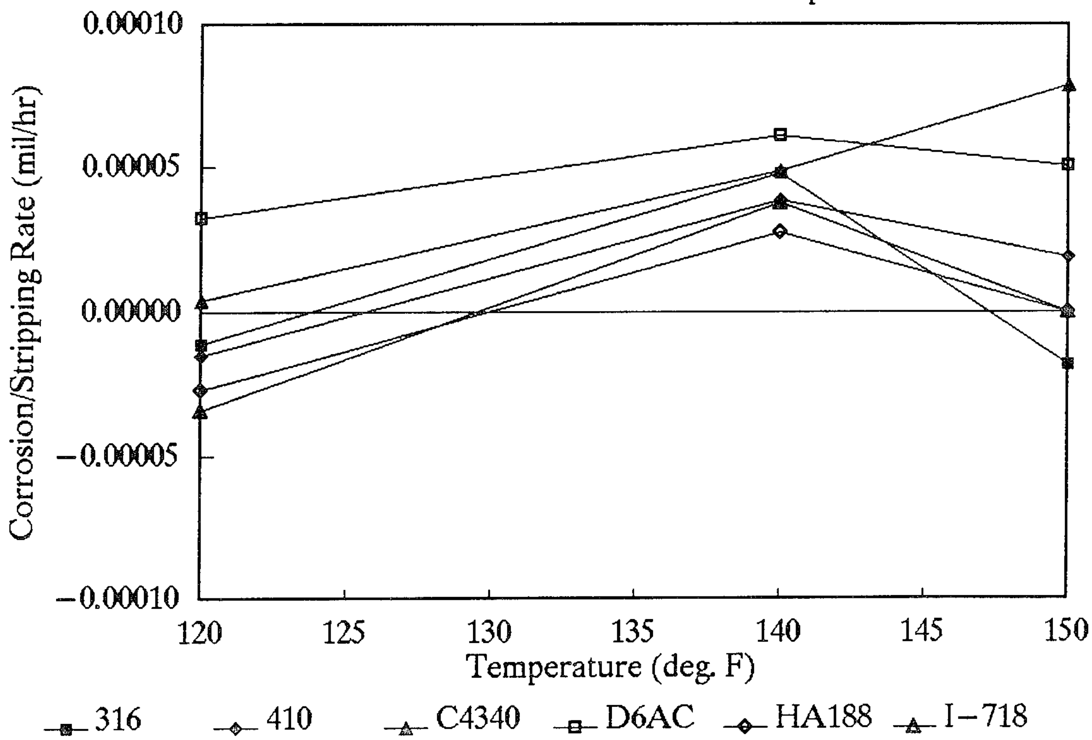


MetalX B-9

Plate Metal Stripping Tests at pH 10



Basis Metal Corrosion Tests at pH 10



MetalX B−9

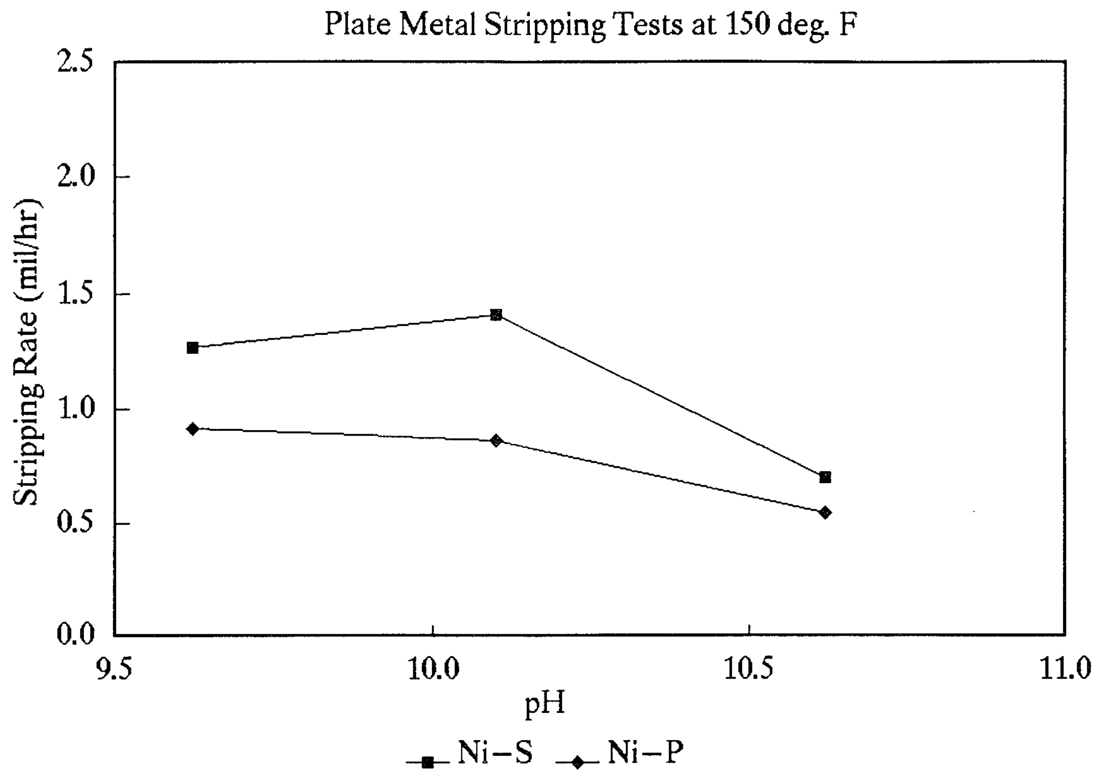
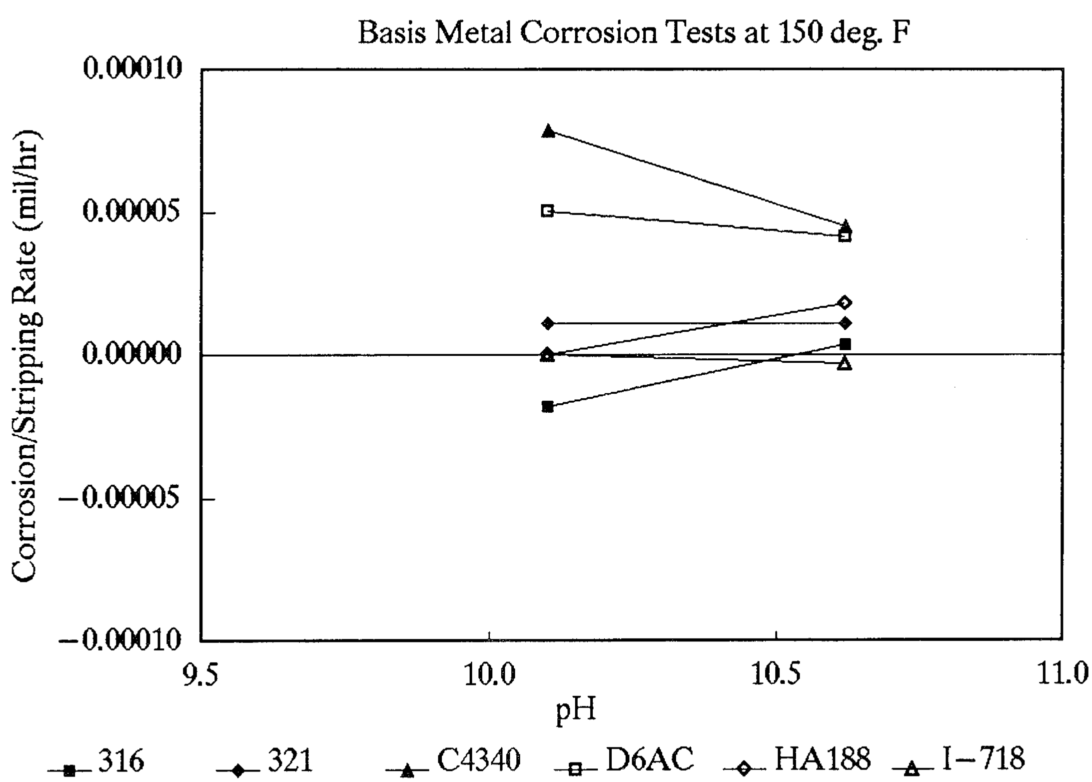
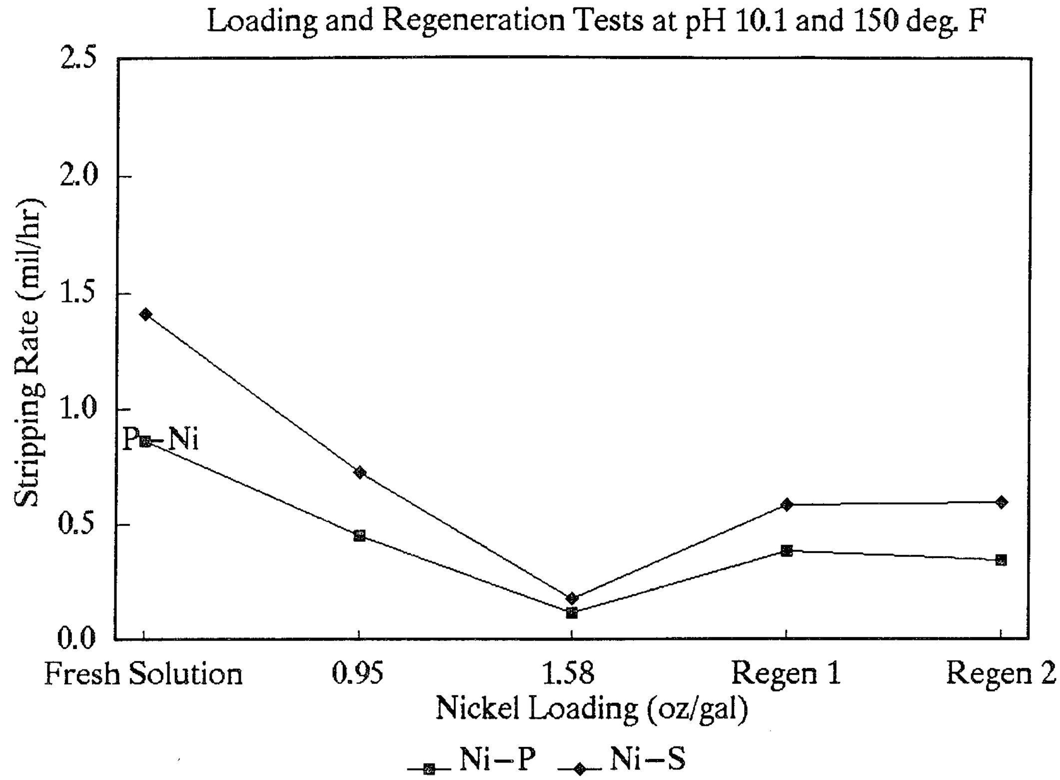


Plate Metal Stripping Tests at 150 deg. F
Stripping Rate (mil/hr)
2.5
2.0
1.5
1.0
0.5
0.0
9.5
10.0
10.5
11.0
pH
Ni−S
Ni−P

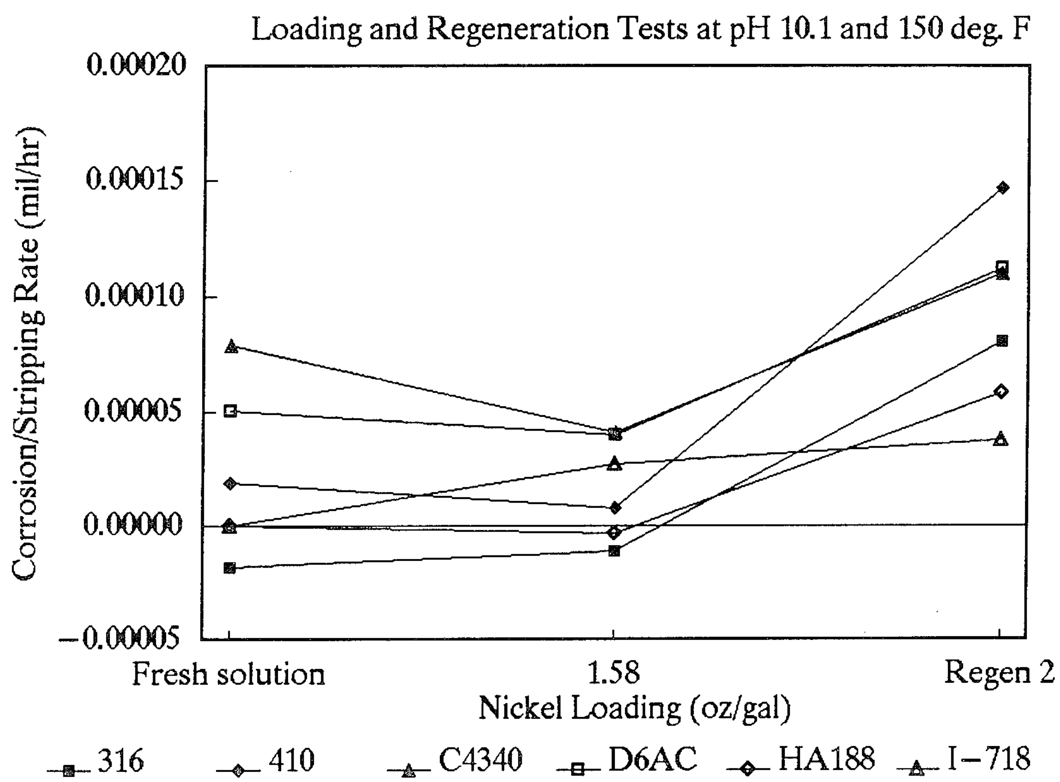


Basis Metal Corrosion Tests at 150 deg. F
Corrosion/Stripping Rate (mil/hr)
0.00010
0.00005
0.00000
−0.00005
−0.00010
9.5
10.0
10.5
11.0
pH
316
321
C4340
D6AC
HA188
I−718

MetalX B−9



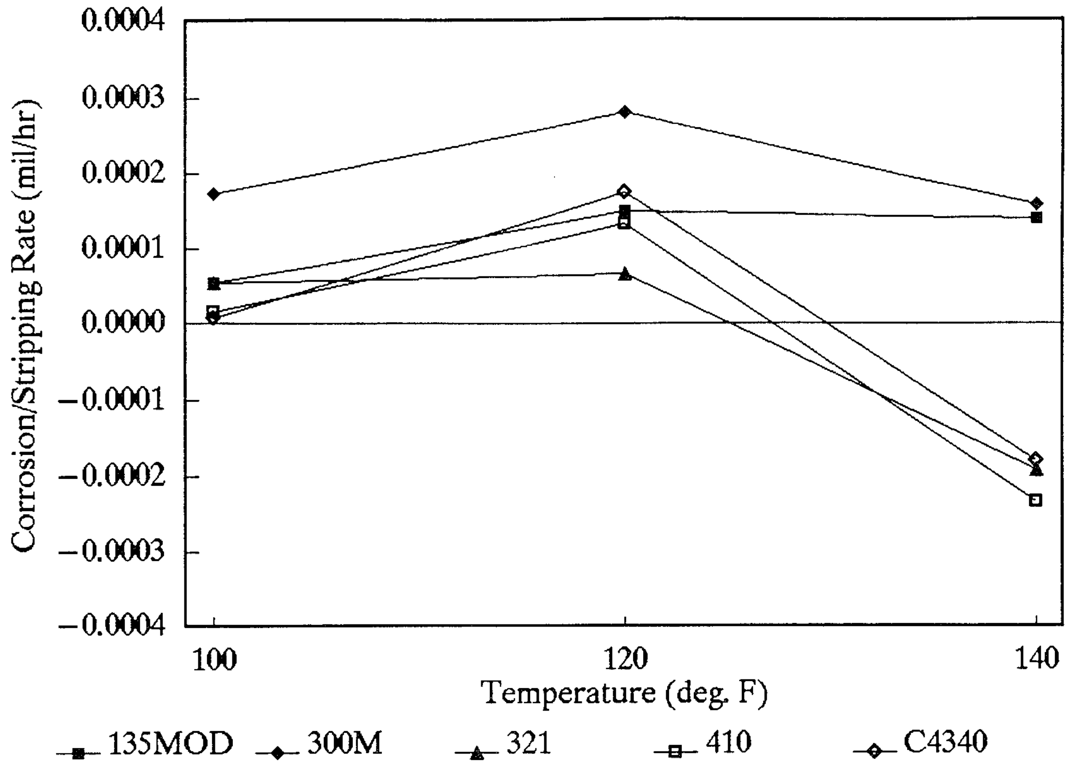
Loading and Regeneration Tests at pH 10.1 and 150 deg. F
2.5
2.0
1.5
1.0
0.5
0.0
Stripping Rate (mil/hr)
P-Ni
Fresh Solution
0.95
1.58
Regen 1
Regen 2
Nickel Loading (oz/gal)
Ni−P
Ni−S



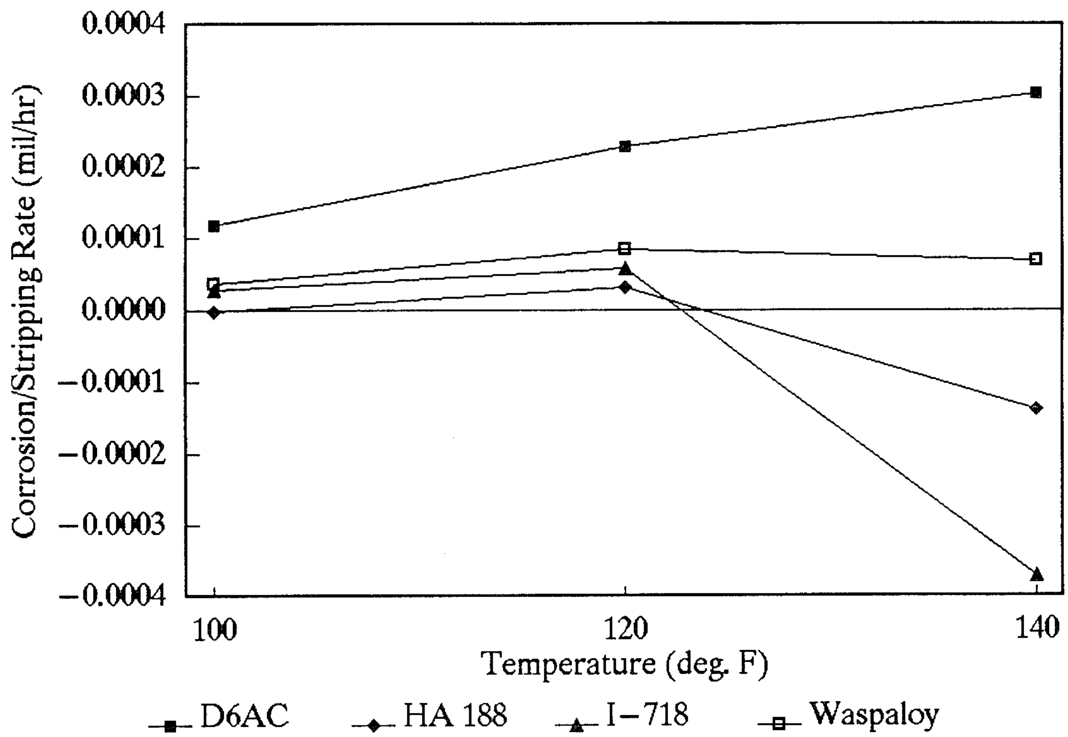
Loading and Regeneration Tests at pH 10.1 and 150 deg. F
0.00020
0.00015
0.00010
0.00005
0.00000
−0.00005
Corrosion/Stripping Rate (mil/hr)
Fresh solution
1.58
Regen 2
Nickel Loading (oz/gal)
316
410
C4340
D6AC
HA188
I−718

OMI International Corp.'s Udylite XPS−306

Basis Metal Corrosion Tests

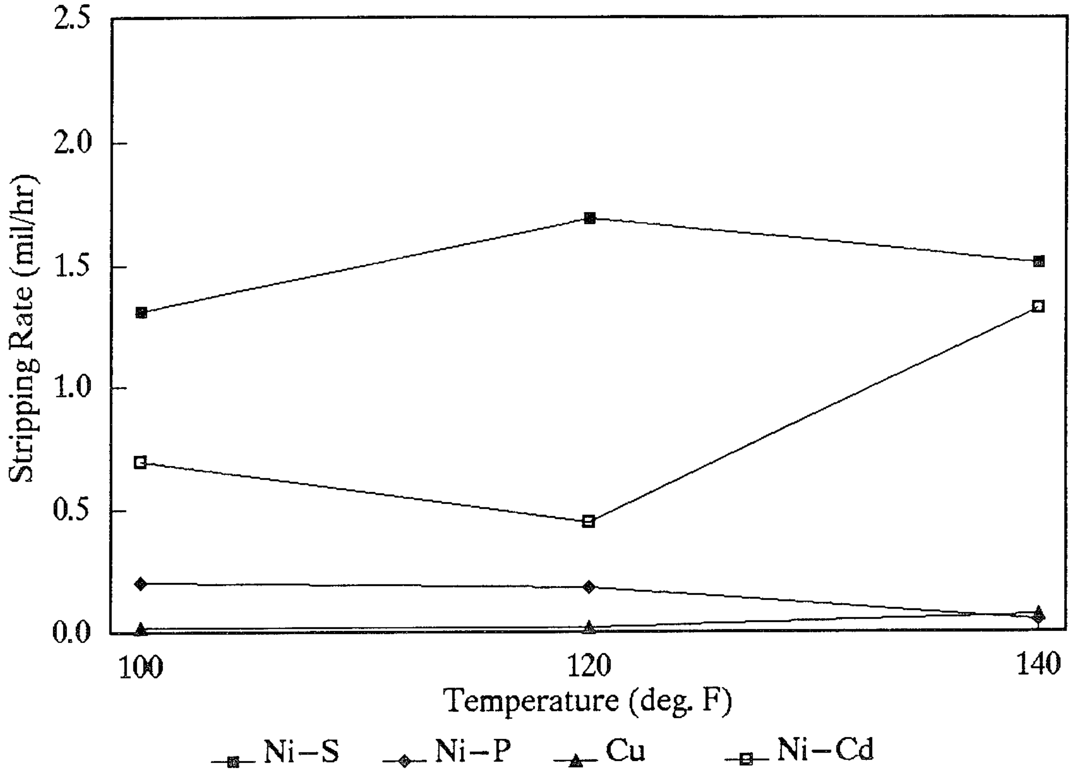


Basis Metal Corrosion Tests

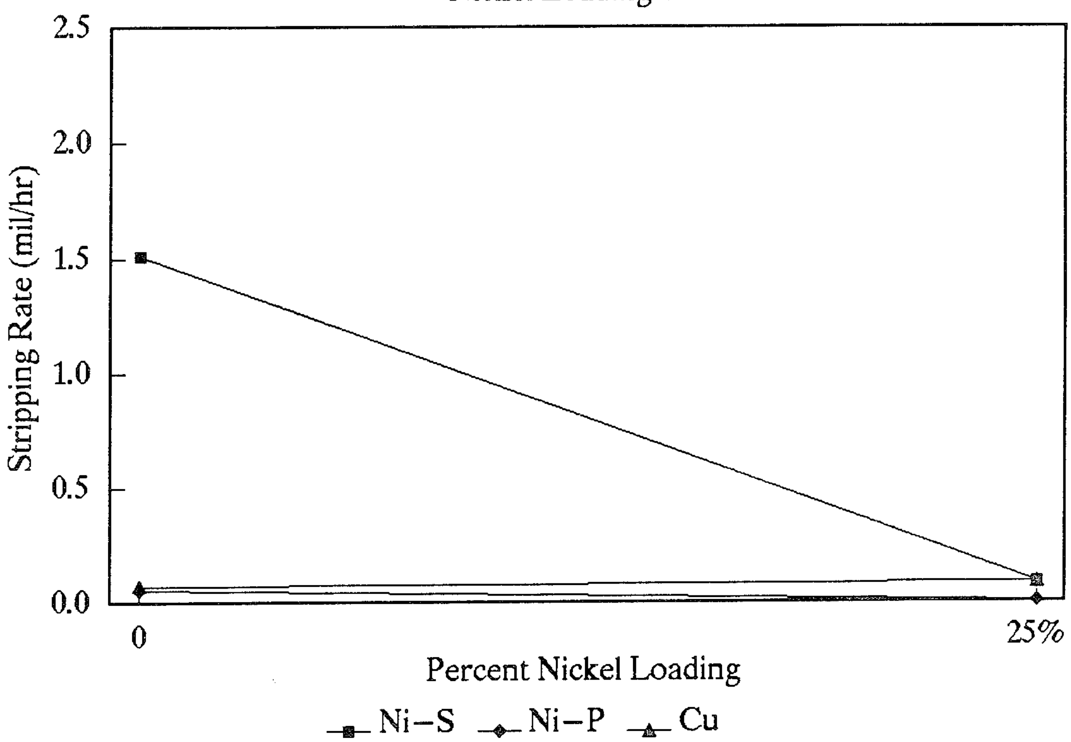


OMI International Corp.'s Udylite XPS-306

Plate Metal Stripping Tests

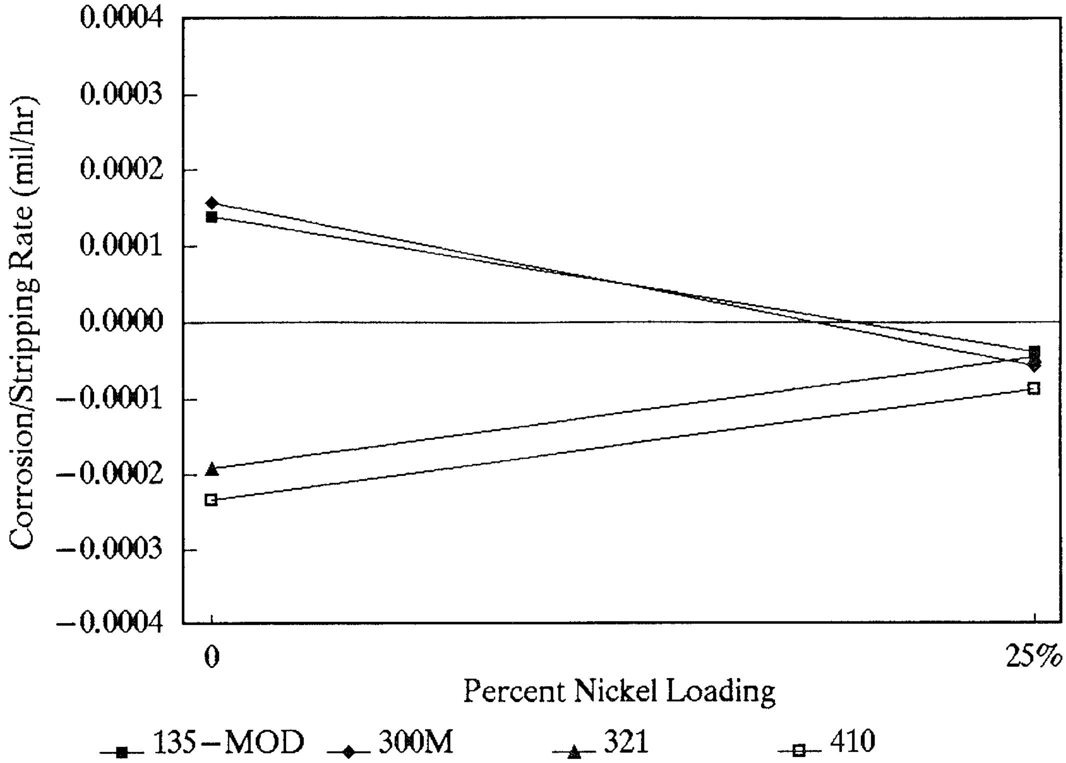


Nickel Loading Tests

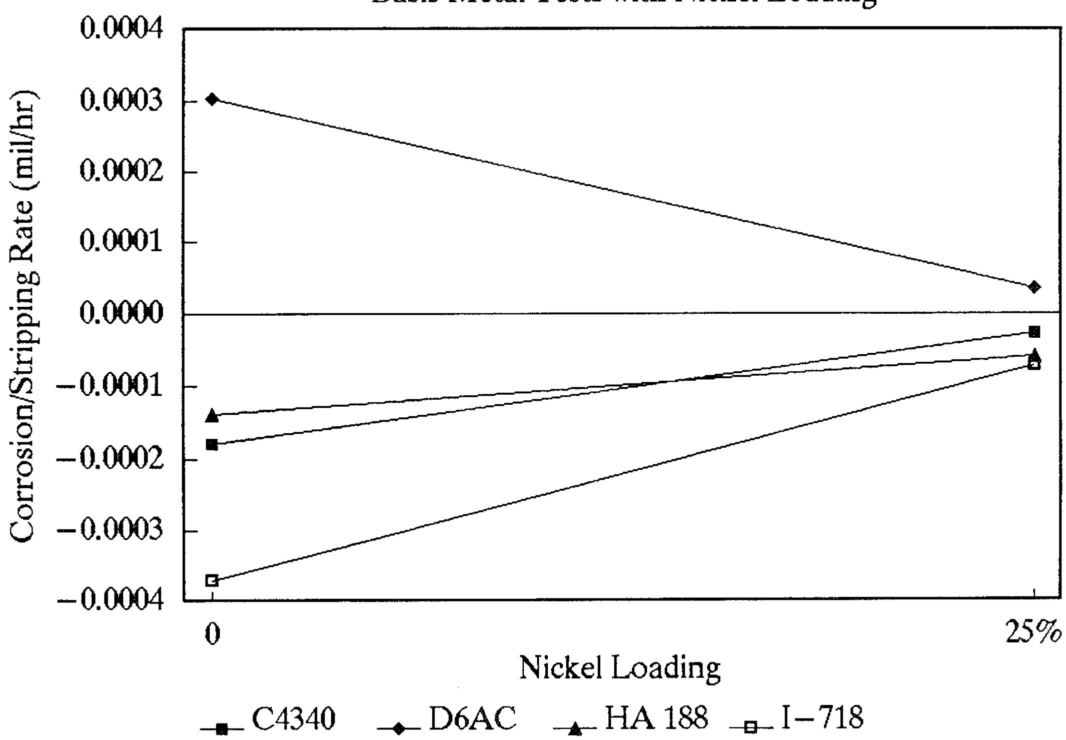


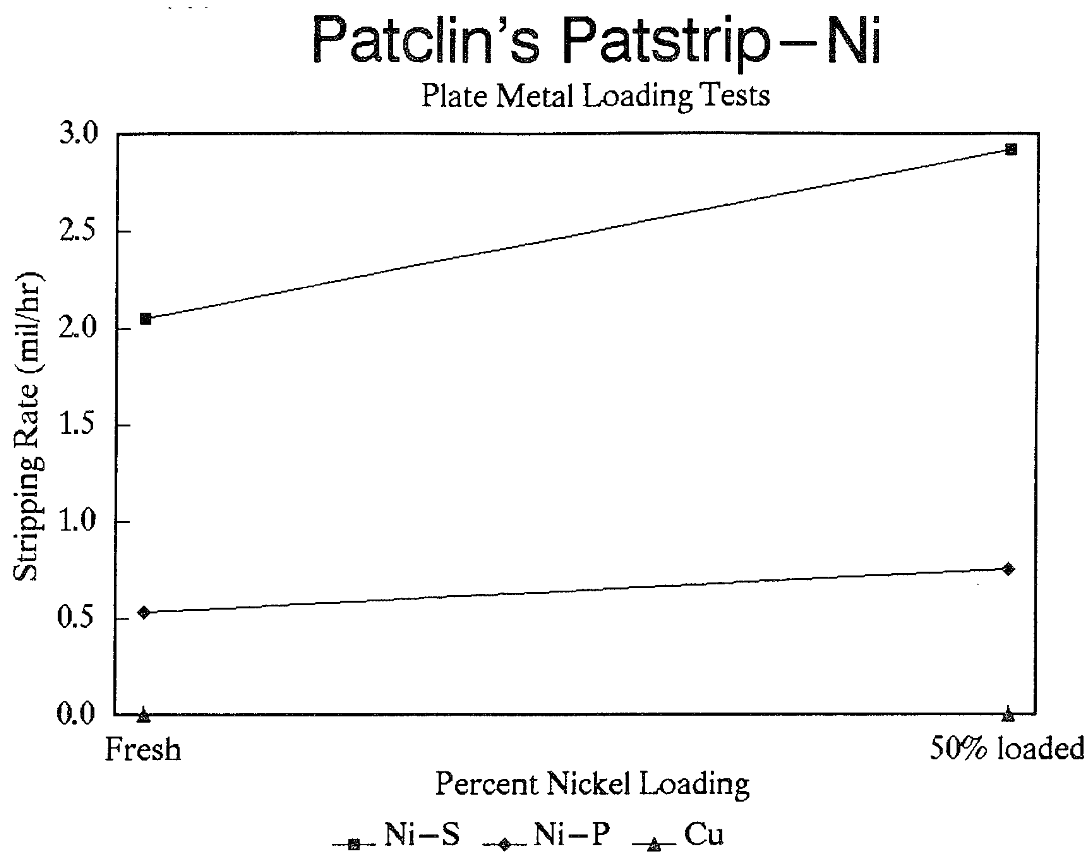
OMI International Corp.'s Udylite XPS–306

Basis Metal Tests with Nickel Loading



Basis Metal Tests with Nickel Loading




Patclin's Patstrip—Ni
Plate Metal Loading Tests
Stripping Rate (mil/hr)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Fresh
50% loaded
Percent Nickel Loading
Ni—S
Ni—P
Cu

APPENDIX M

GRAPHICAL PRESENTATION OF THE SILVER STRIPPER FIELD-TEST DATA FROM PHASE III

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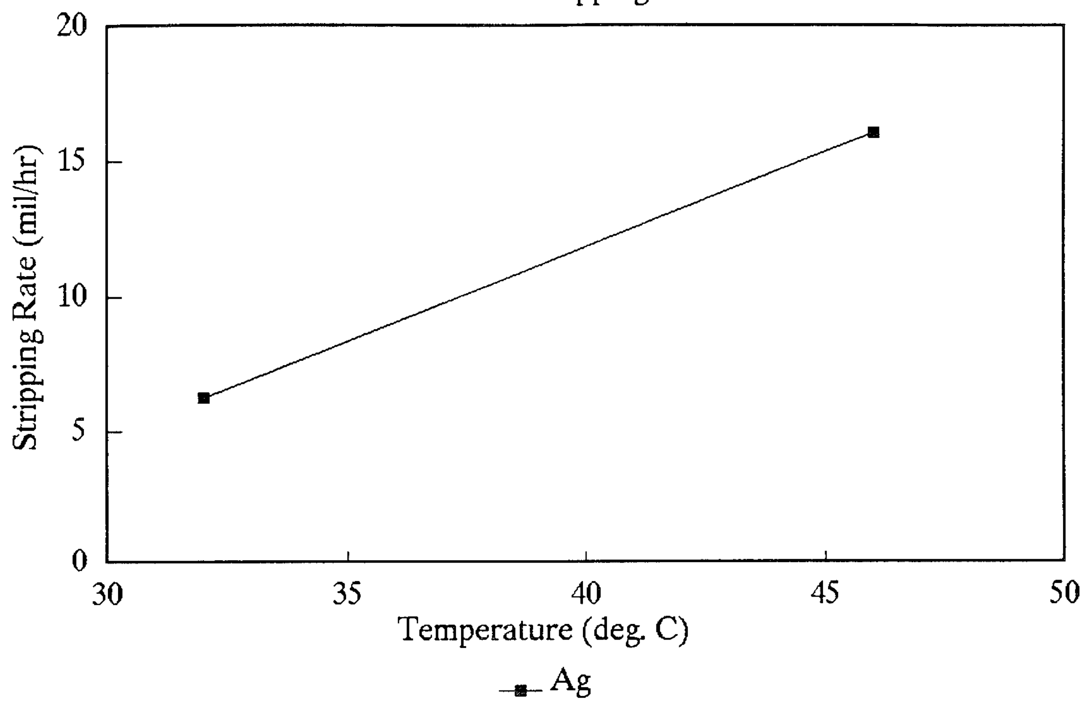
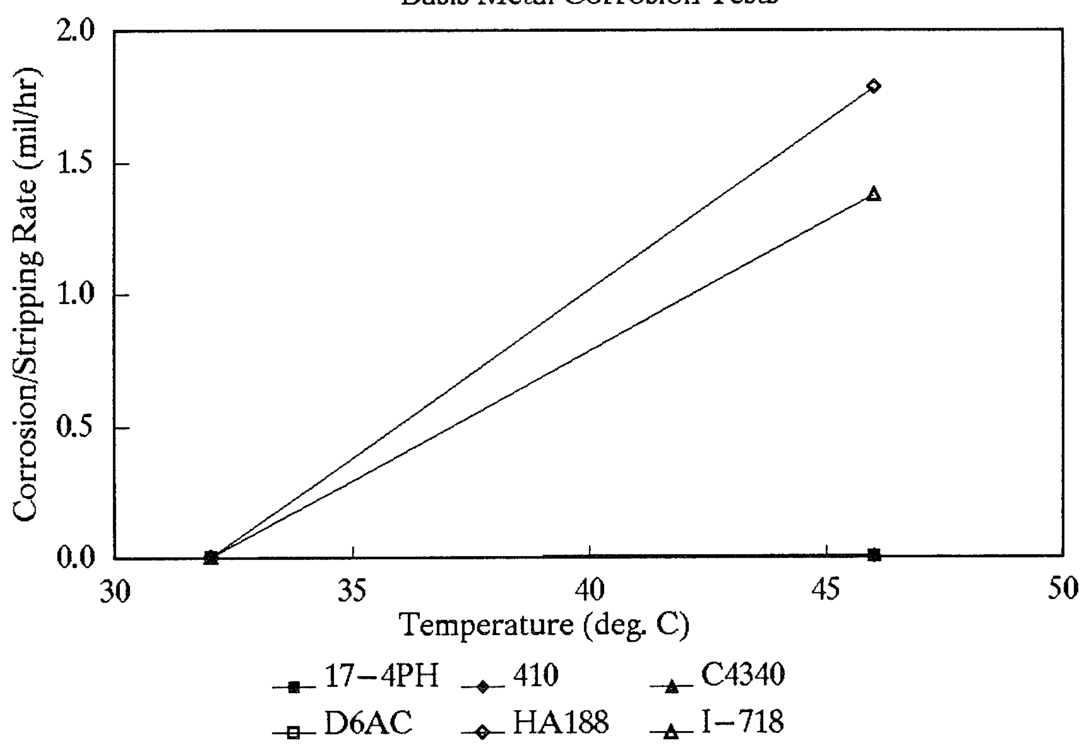
McGean–Rohco's Rostrip 999***

Silver Stripping Tests

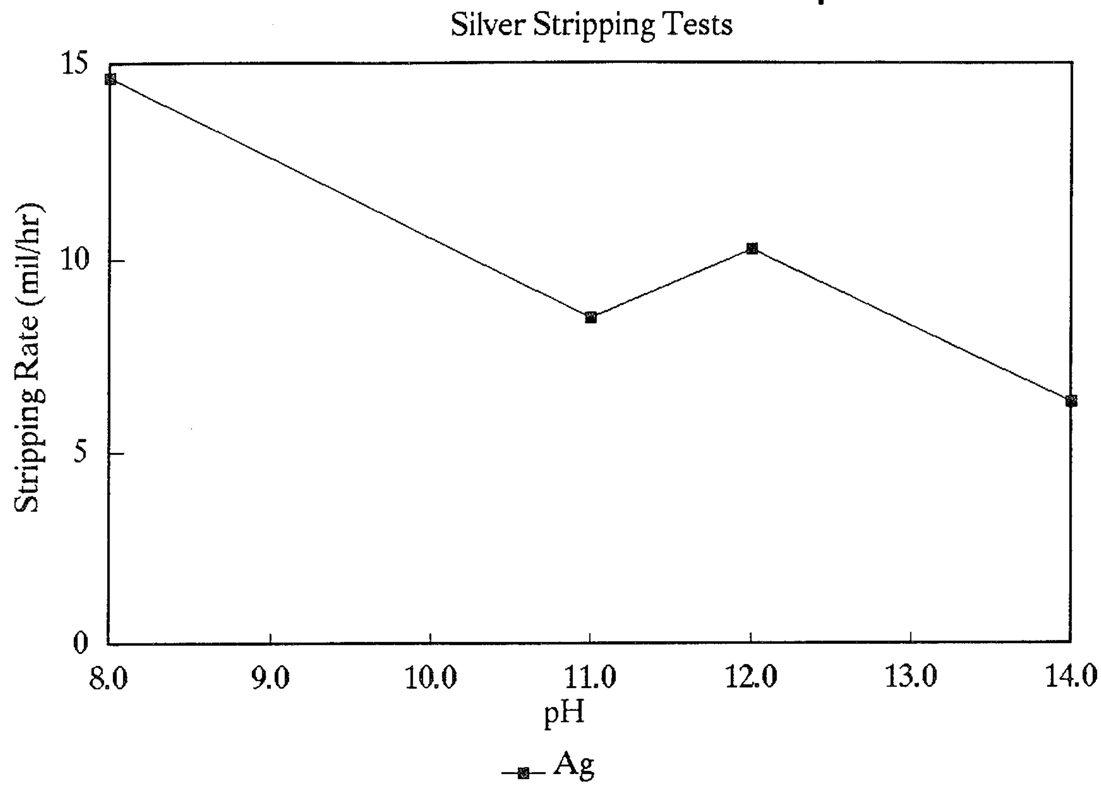


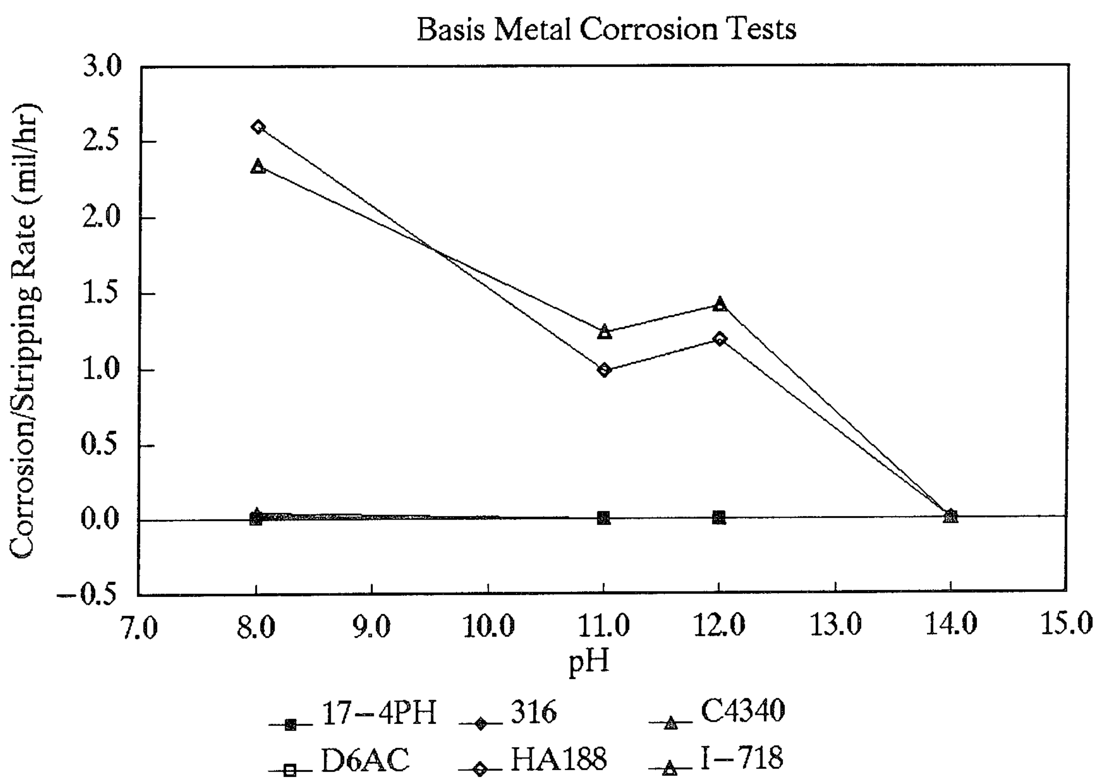
*** Note expanded scale

Basis Metal Corrosion Tests

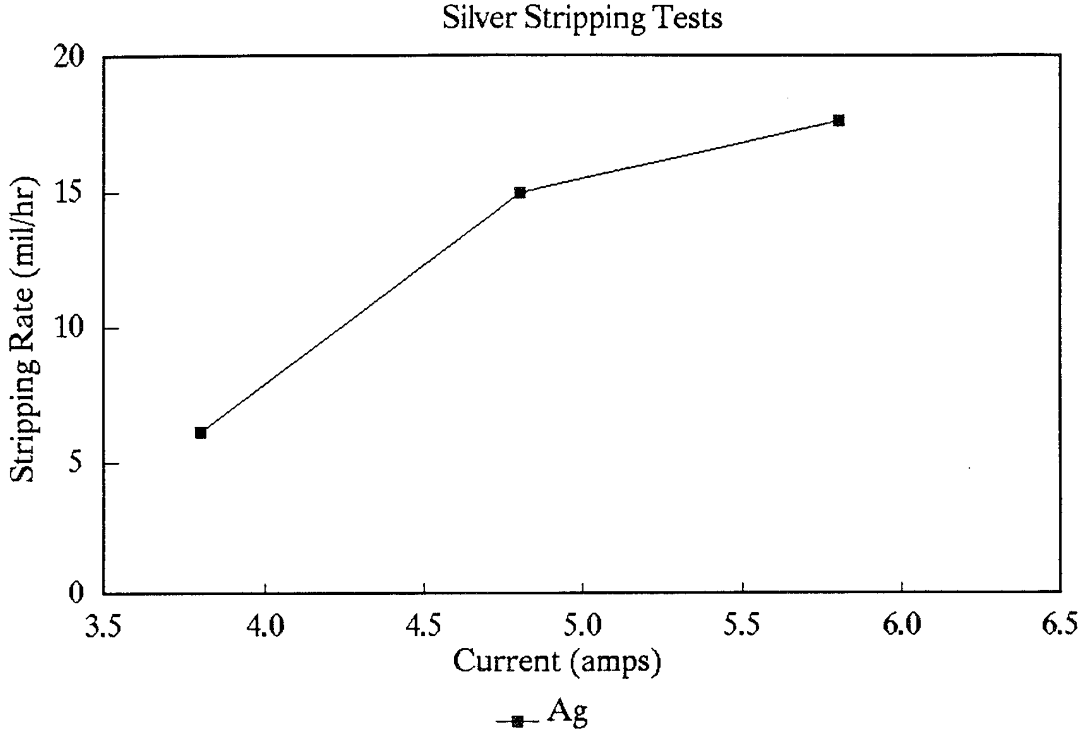


McGean–Rohco's Rostrip 999***

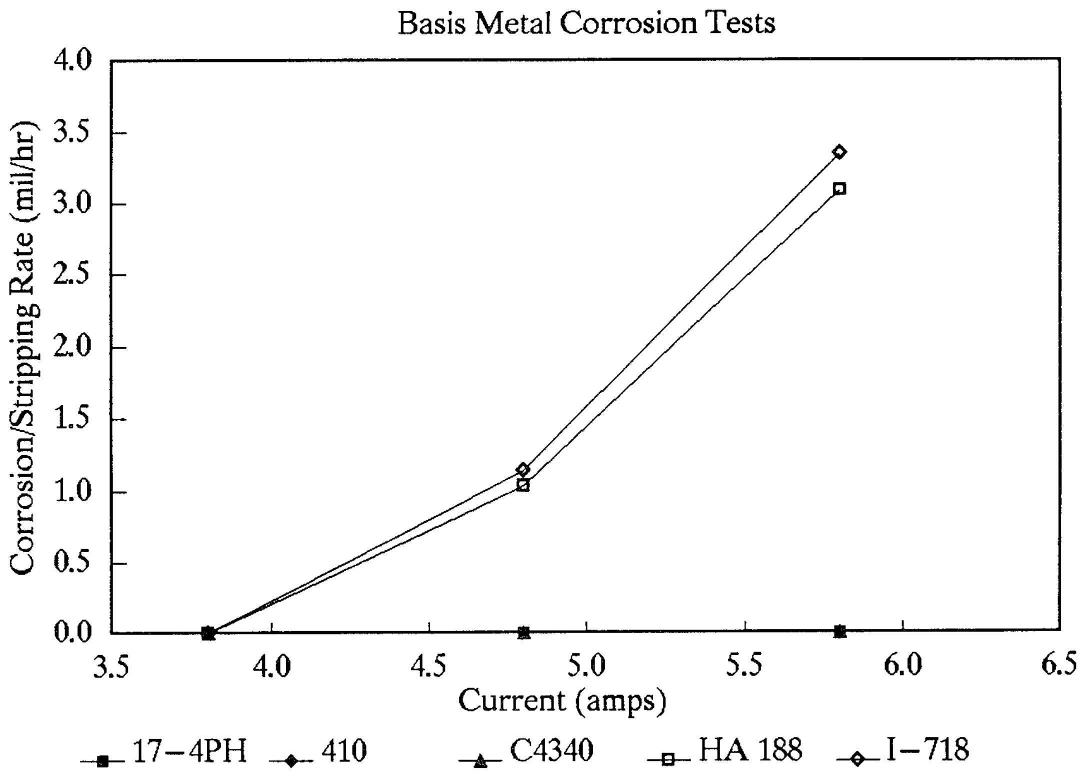




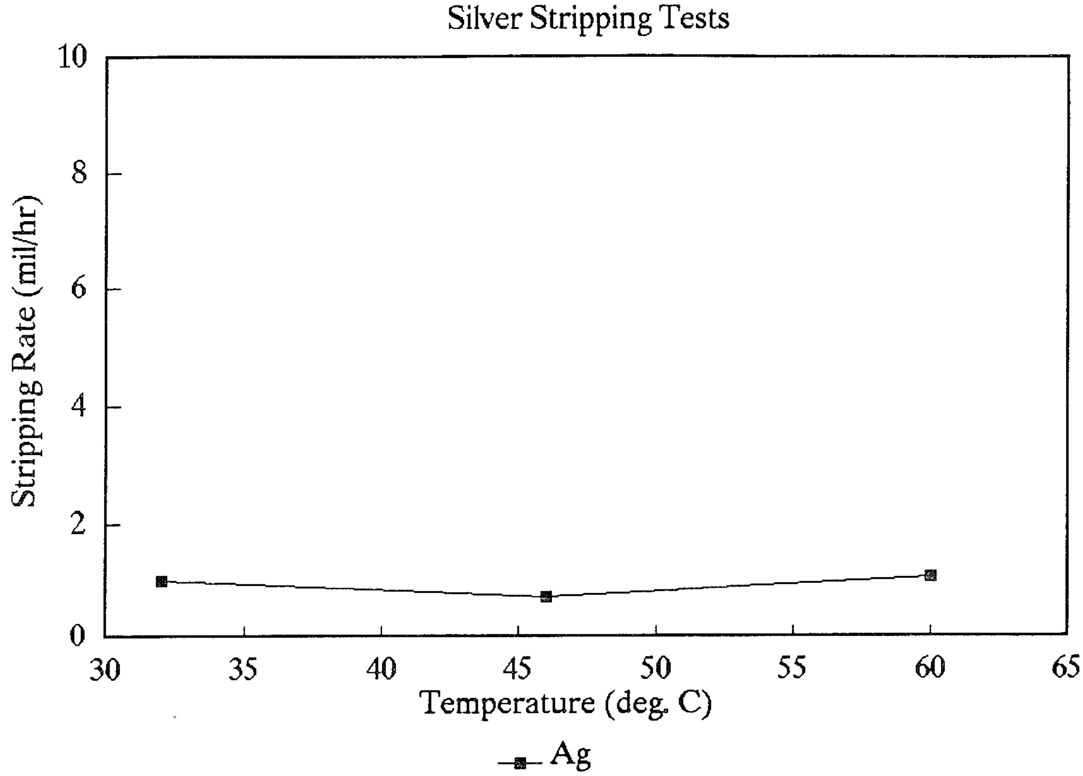
McGean-Rohco's Rostrip 999***

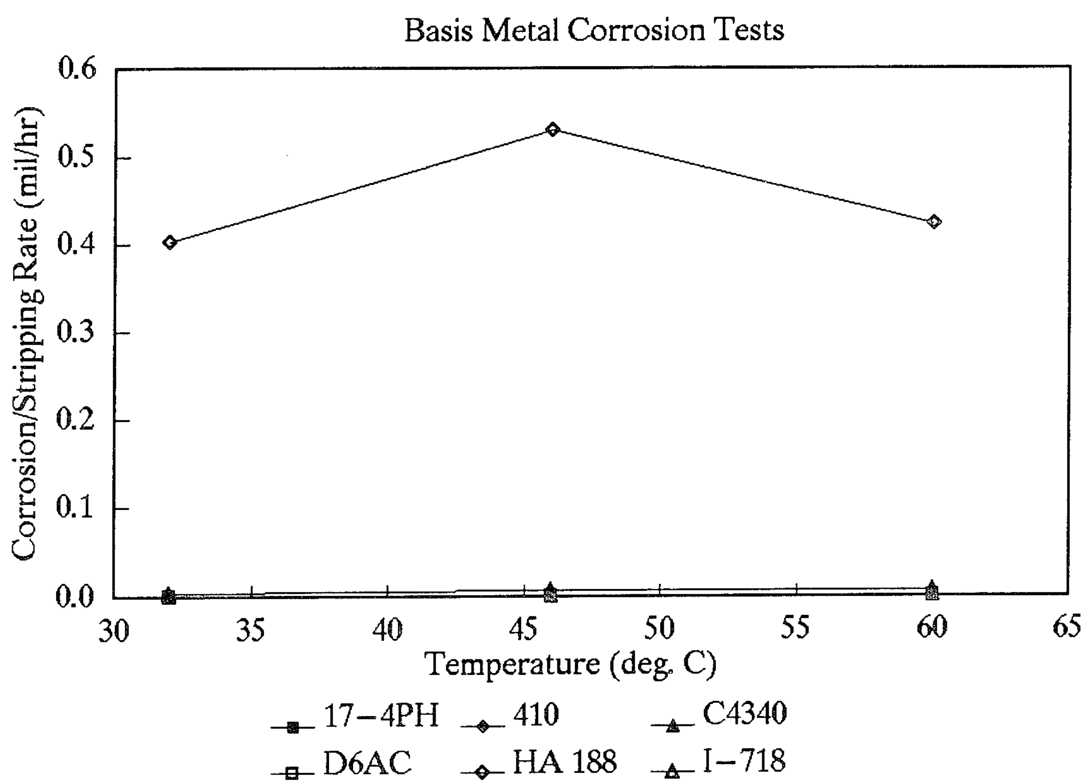


*** Note expanded scale

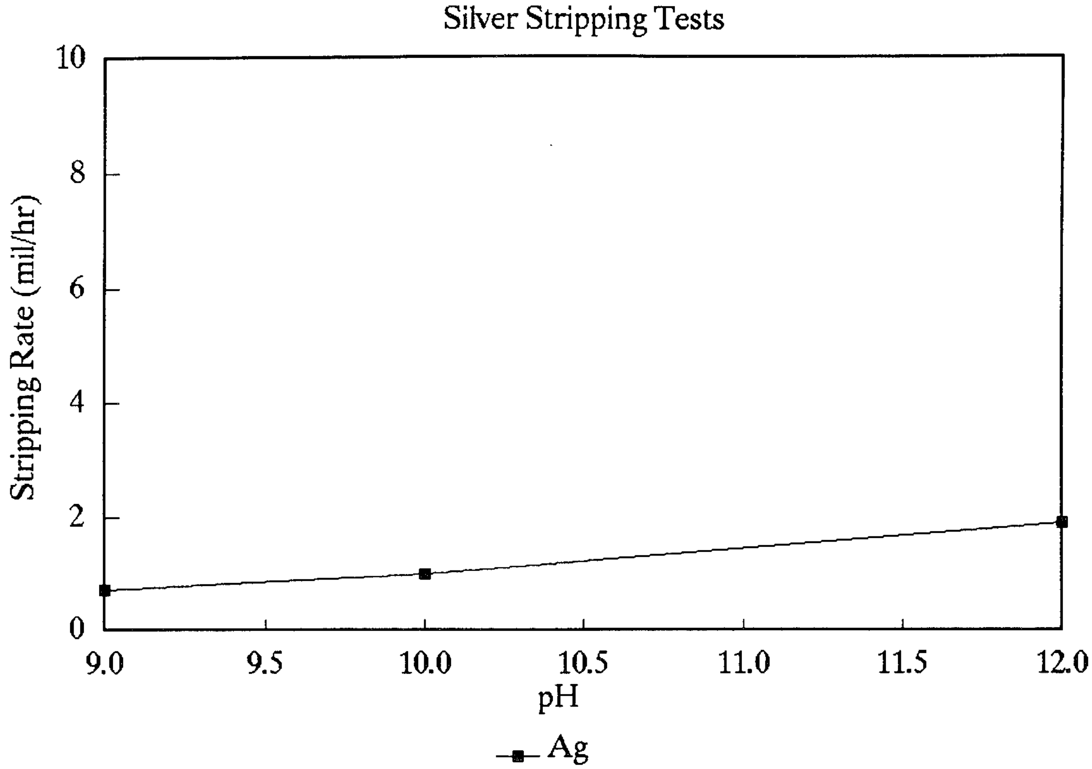


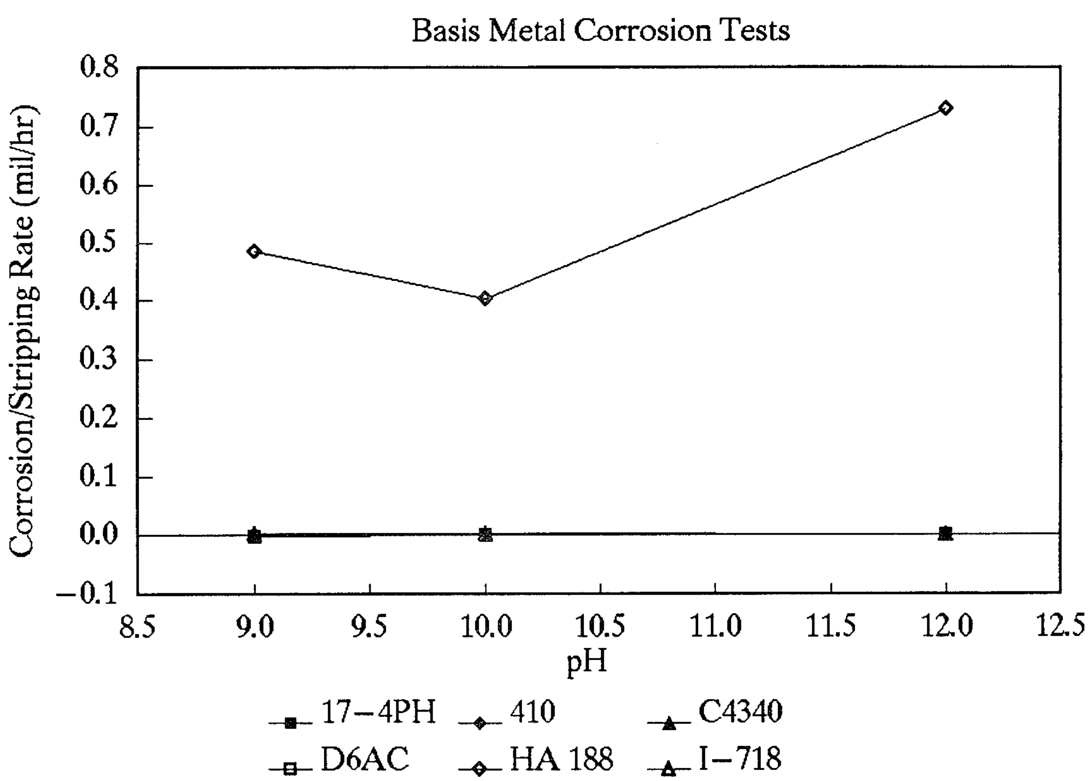
Technic's Non–Cyanide Silver Stripper



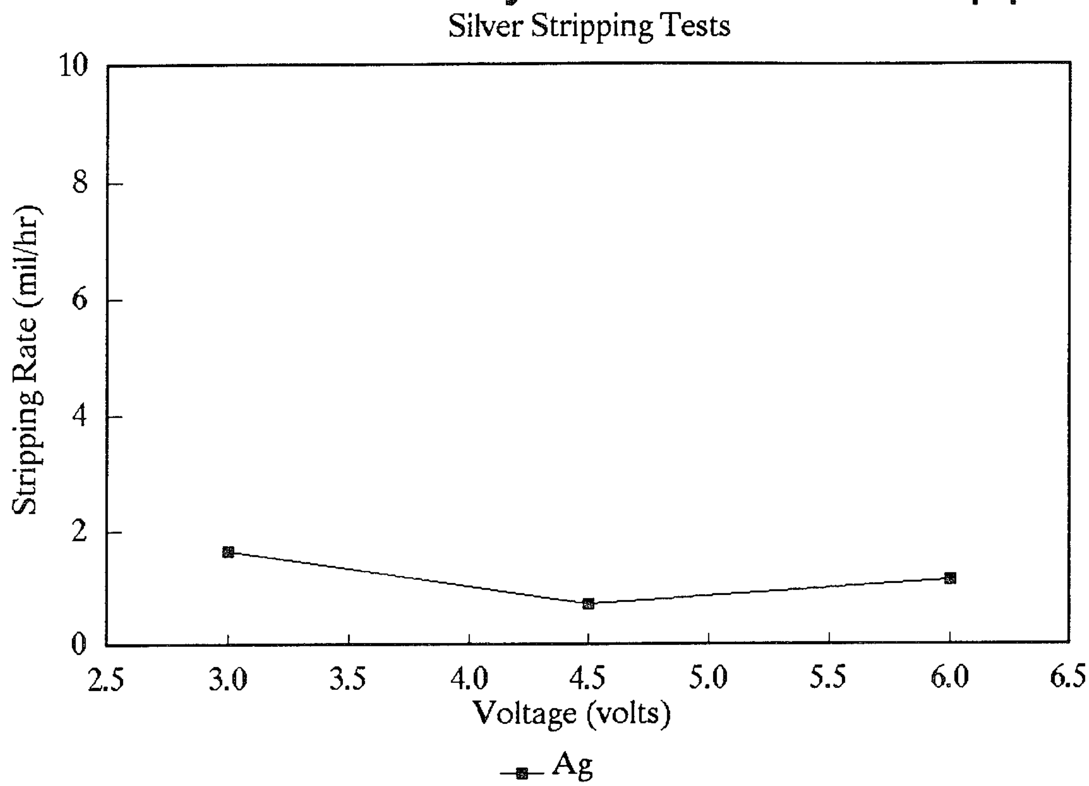


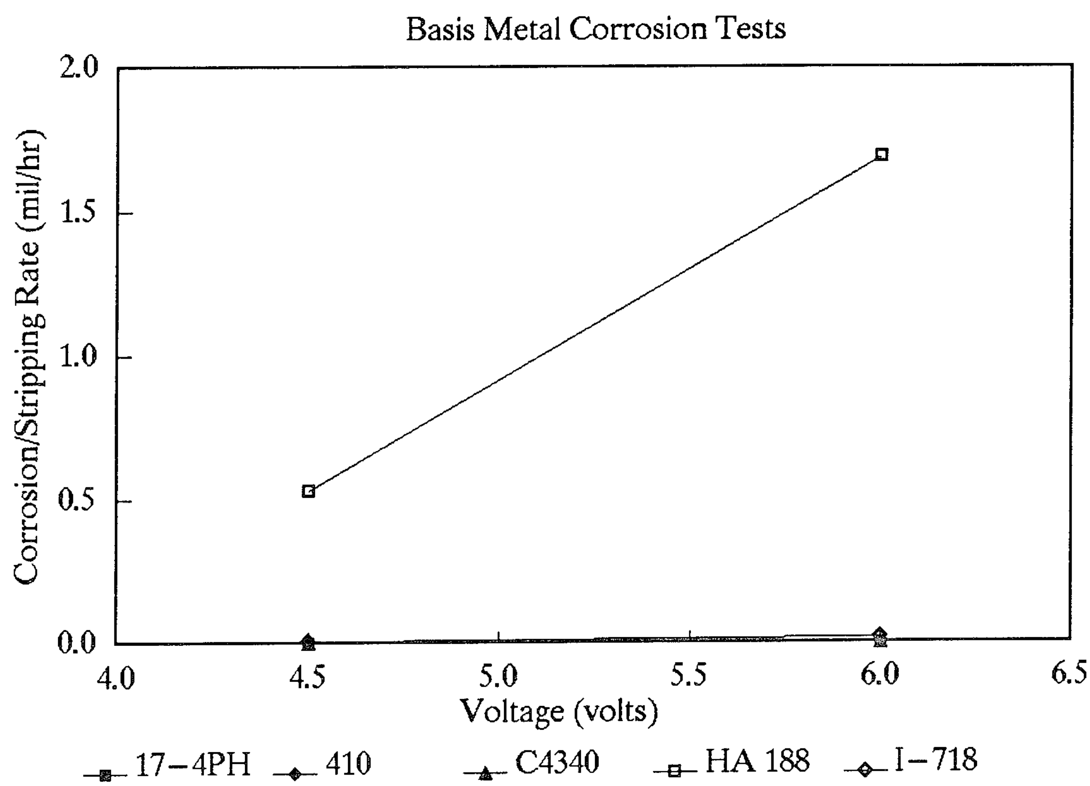
Technic's Non-Cyanide Silver Stripper





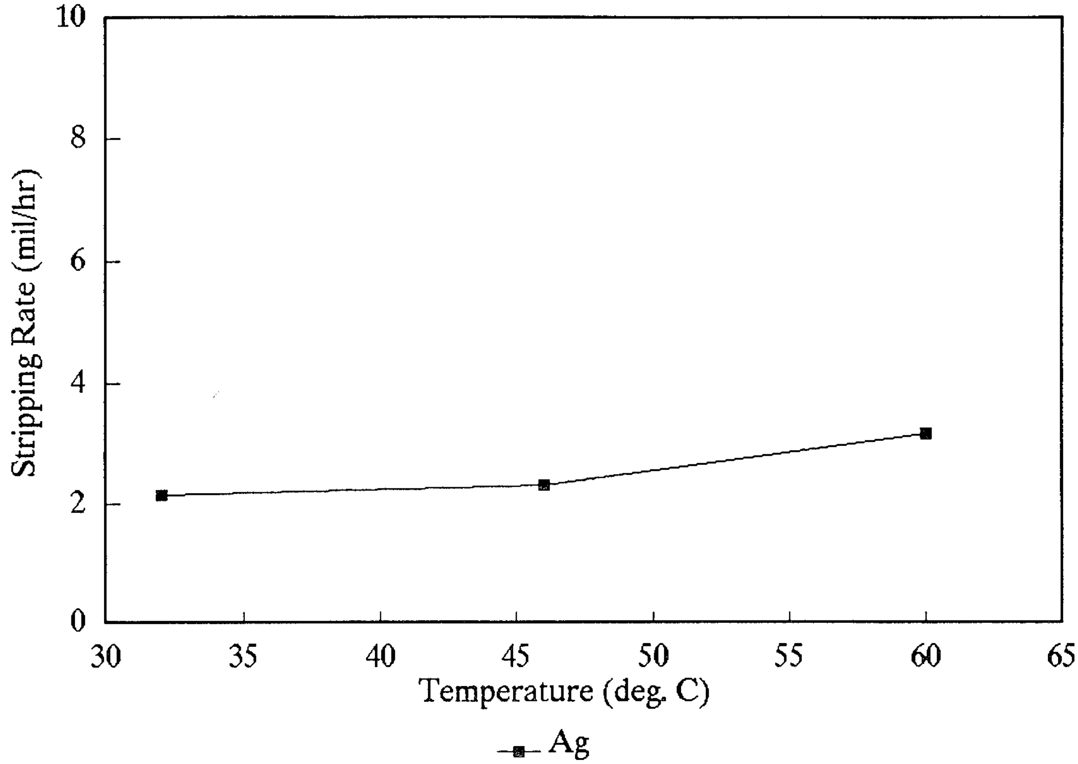
Technic's Non–Cyanide Silver Stripper



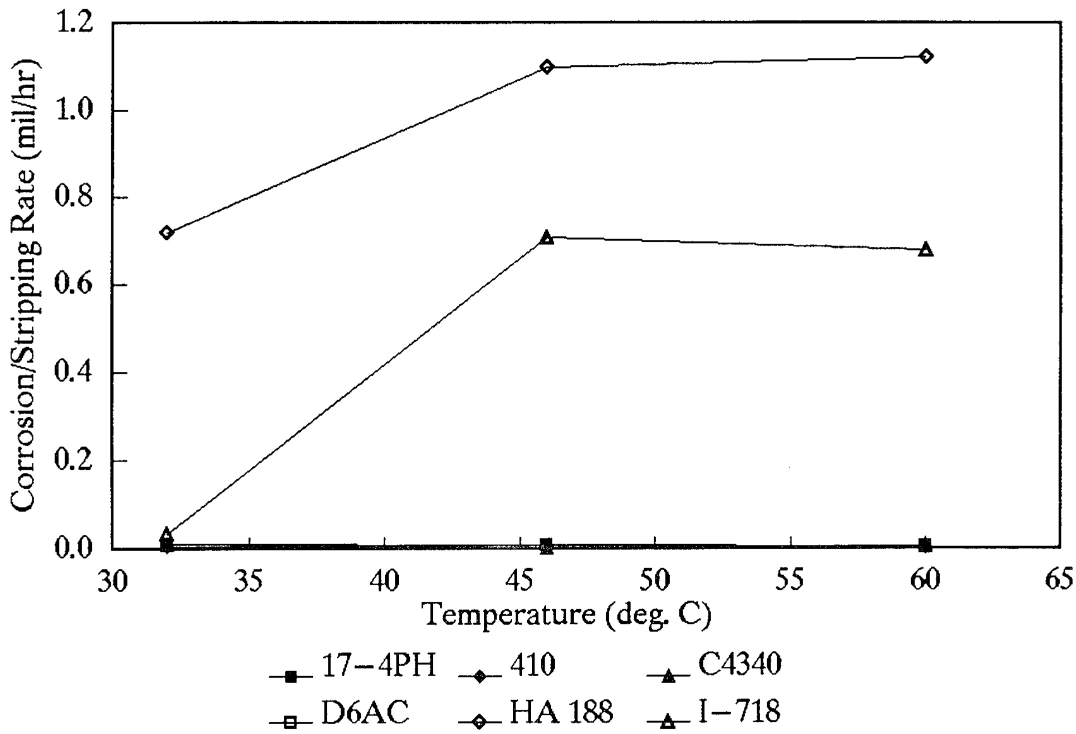


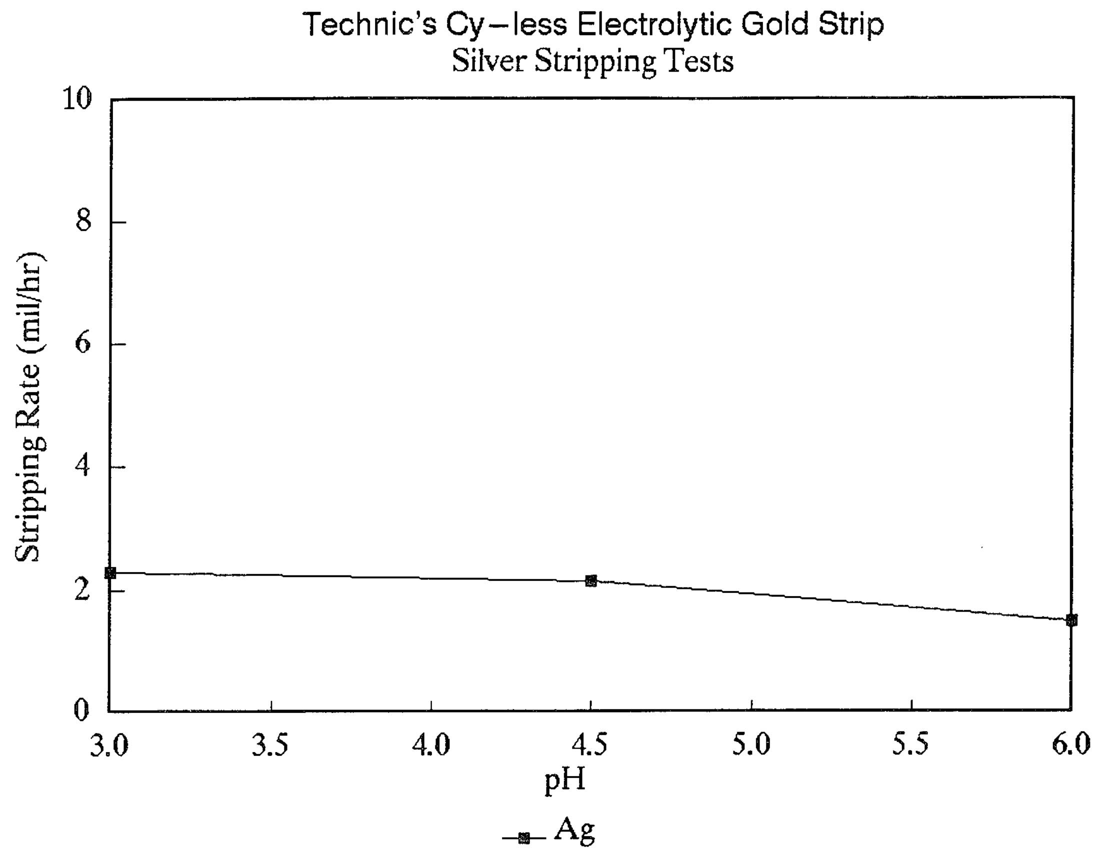
Technic's Cy–less Electrolytic Gold Strip

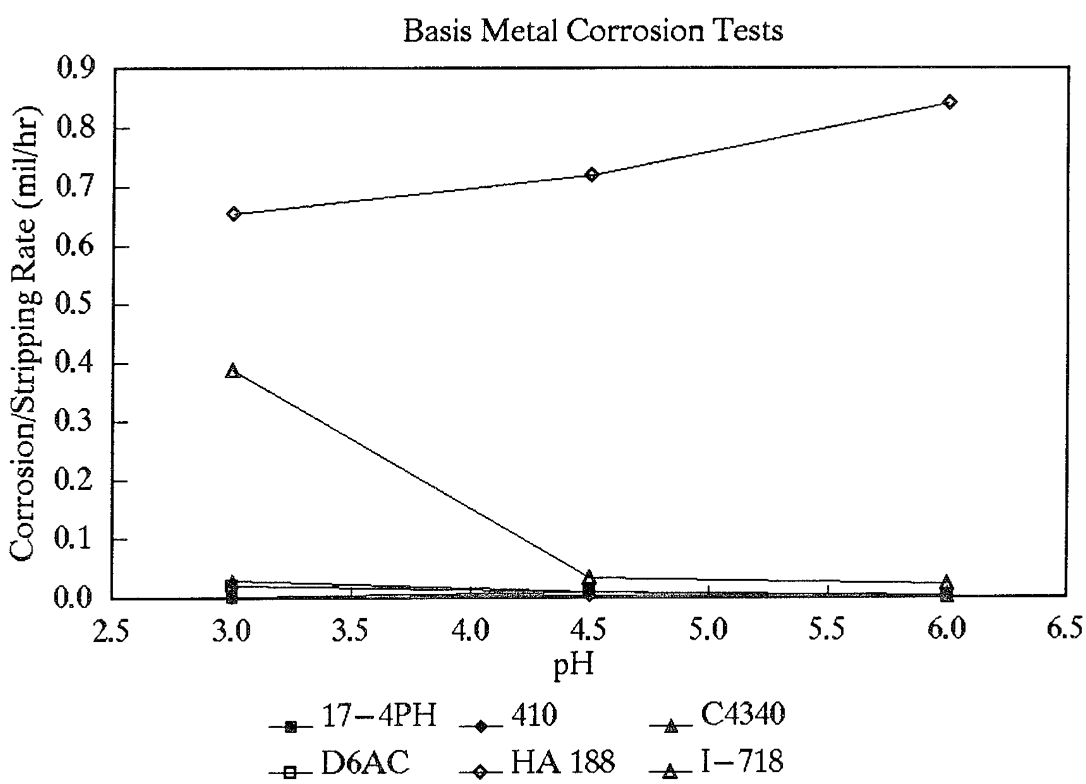
Silver Stripping Tests



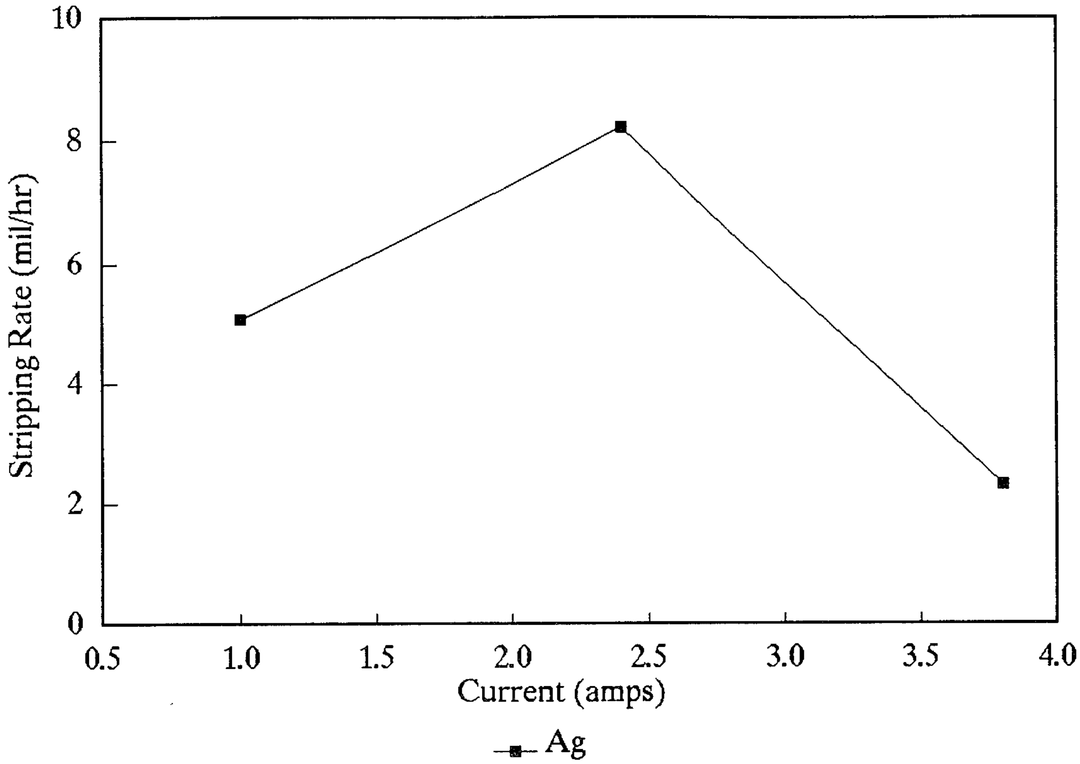
Basis Metal Corrosion Tests



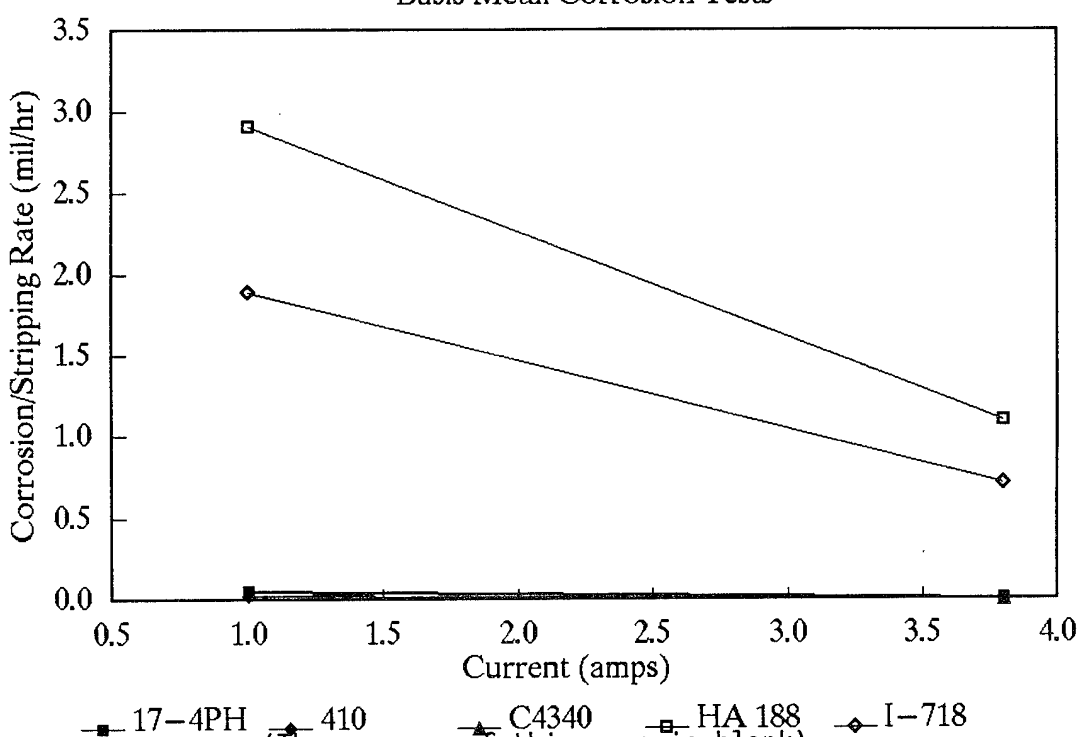

Technic's Cy–less Electrolytic Gold Strip
Silver Stripping Tests
Stripping Rate (mil/hr)
10
8
6
4
2
0
3.0
3.5
4.0
4.5
5.0
5.5
6.0
pH
Ag


Basis Metal Corrosion Tests
Corrosion/Stripping Rate (mil/hr)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
pH
17–4PH
410
C4340
D6AC
HA 188
I–718

Technic's Cy–less Electrolytic Gold Strip
Silver Stripping Tests



Basis Metal Corrosion Tests



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APPENDIX N

STRIPPING RATE DATA FOR THE LABORATORY TESTING OF GENERIC NICKEL-STRIPPING FORMULATIONS

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Solution	Solution Composition	Concentration	Stripping Rate (mil/hr)	Metals Tested
24	Ethylenediamine	3.7 M	2.5	S-Ni
	Nitric Acid	1.0 M	0.025	P-Ni
	Sodium Nitrate	0.6 M		
	Sodium *m*-nitrobenzenesulfonate	0.67 M		
	Ammonium Thiocyanate	0.05 M		
21	Ammonium Thiocyanate	1.0 M	1.3	S-Ni
	Sodium Hydroxide	1.0 M	0.60	P-Ni
	Ammonium Nitrate	0.62 M	0.018	4340
	Sodium *m*-nitrobenzenesulfonate	0.44 M		
1	Ethylenediamine	3.7 M	1.3	S-Ni
	Nitric Acid	1.0 M	0.034	P-Ni
	Ammonium Nitrate	0.62 M	0.00	4340
	Sodium *m*-nitrobenzenesulfonate	0.67 M		
5	Ethylenediamine	3.7 M	0.94	S-Ni
	Nitric Acid	1.0 M	0.034	P-Ni
	Ammonium Nitrate	0.62 M		
	Sodium *m*-nitrobenzenesulfonate	0.67 M		
	Hydrogen Peroxide	0.50 M		
14	Ammonium Thiocyanate	1.0 M	0.82	S-Ni
	Sodium Hydroxide	1.0 M	0.48	P-Ni
	Ammonium Nitrate	0.62 M		
	Sodium *m*-nitrobenzenesulfonate	0.22 M		
3	Ethylenediamine	3.0 M	0.77	S-Ni
	Nitric Acid	1.6 M	0.40	P-Ni
	Sodium *m*-nitrobenzenesulfonate	0.22 M		
22	Glycine	1.4 M	0.65	S-Ni
	Sodium Carbonate	1.1 M	0.33	P-Ni
	Sodium Thiosulfate	0.08 M		
	Sodium *m*-nitrobenzenesulfonate	0.29 M		
4	Ethylenediamine	3.7 M	0.49	S-Ni
	Acetic Acid	1.0 M	0.040	P-Ni
	Ammonium Nitrate	0.62 M		
	Sodium *m*-nitrobenzenesulfonate	0.67 M		
9	Glycine	2.0 M	0.33	S-Ni
	Sodium Hydroxide	2.0 M	0.019	P-Ni
	Ammonium Nitrate	1.2 M		
	Sodium *m*-nitrobenzenesulfonate	0.67 M		
8	Ethanolamine	4.1 M	0.19	S-Ni
	Ammonium Nitrate	1.9 M	0.015	P-Ni
	Sodium *m*-nitrobenzenesulfonate	0.67 M		

Solution	Solution Composition	Concen-tration	Stripping Rate (mil/hr)	Metals Tested
6	Ethylenediamine	3.7 M	0.19	S-Ni
	Nitric Acid	1.0 M	0.033	P-Ni
	Ammonium Nitrate	0.62 M		
	Sodium *m*-nitrobenzenesulfonate	0.67 M		
	Potassium Persulfate	0.18 M		
7	Ethanolamine	4.1 M	0.16	S-Ni
	Nitric Acid	1.0 M	0.025	P-Ni
	Ammonium Nitrate	0.62 M		
	Sodium *m*-nitrobenzenesulfonate	0.67 M		
23	Sodium Thiosulfate	1.0 M	0.11	S-Ni
	Sodium Hydroxide	0.5 M		
	Ammonium Nitrate	0.62 M		
	Sodium *m*-nitrobenzenesulfonate	0.44 M		
2	Ethylenediamine	3.7 M	0.047	P-Ni
	Nitric Acid	1.0 M		
	Ammonium Nitrate	0.62 M		
	Sodium *m*-nitrobenzenesulfonate	0.67 M		
	Sodium Dodecylsulfate	0.03 M		
18	Methionine	1.0 M	0.041	S-Ni
	Sodium Hydroxide	1.0 M		
	Ammonium Nitrate	0.62 M		
	Sodium *m*-nitrobenzenesulfonate	0.22 M		
16	Cystine	0.5 M	0.040	S-Ni
	Sodium Hydroxide	1.0 M		
	Ethylenediamine	1.5 M		
17	Cystine	0.5 M	0.024	S-Ni
	Sodium Hydroxide	1.0 M		
	Ammonium Nitrate	0.62 M		
	Sodium *m*-nitrobenzenesulfonate	0.22 M		
15	Ammonium Thiocyanate	1.0 M	0.022	S-Ni
	Sodium Hydroxide	2.0 M		
	Glycine	1.0 M		
	Hydrogen Peroxide	3% v		
10	Ammonium Thiocyanate	1.0 M	0.013	S-Ni
	Sodium Hydroxide	1.0 M	0.0083	P-Ni
19	Methionine	1.0 M	0.011	S-Ni
	Sodium Hydroxide	1.0 M		
	Ethylenediamine	1.5 M		
	Hydrogen Peroxide	3% v		
13	Ammonium Thiocyanate	1.0 M	0.0059	S-Ni
	Sodium Hydroxide	1.0 M		
	Ethylenediamine	1.5 M		

Solution	Solution Composition	Concen-tration	Stripping Rate (mil/hr)	Metals Tested
20	Methionine	1.0 M	0.0039	S-Ni
	Sodium Hydroxide	1.0 M		
	Ethylenediamine	1.5 M		
12	Methionine	1.0 M	0.0035	S-Ni
	Sodium Hydroxide	1.0 M	0.0035	P-Ni
11	Cystine	0.5 M	0.0019	S-Ni
	Sodium Hydroxide	1.0 M	0.0015	P-Ni
	other solutions as PAP and Tafel tests indicate			

Stripper Solution	Test Date	Coupon Material	Coupon #	Density (g/cm3)	Unmasked Dimensions in mm length	width	thick	hole diam. (mm)	Surface Area (cm2)	Initial Mass (grams)	Final Mass (grams)	Mass Loss (grams)	Total Time (hrs)	Stripping Rate (mil/hr)	Average S.R. (mil/hr)
1	6-19-90	Ni-S	1	8.90	51.46	26.33	1.98	5.93	30.00	19.8653	18.7383	1.1270	1.000	1.6620	1.5218
1	6-19-90	Ni-S	2	8.90	51.77	26.31	1.93	5.93	30.06	20.2777	19.1750	1.1027	1.033	1.5708	
1	6-19-90	Ni-S	3	8.90	51.53	26.31	1.87	5.95	29.82	18.9977	18.0694	0.9283	1.033	1.3327	
1	6-19-90	Ni-S	4	8.90	51.90	26.50	2.05	6.15	30.52	20.4466	19.4949	0.9517	1.000	1.3793	1.3685
1	6-19-90	Ni-S	5	8.90	51.72	26.11	1.84	6.08	29.64	18.6485	17.9053	0.7432	1.000	1.1091	
1	6-19-90	Ni-S	6	8.90	52.18	26.46	1.98	5.80	30.56	20.4580	19.3407	1.1173	1.000	1.6173	
1	6-20-90	Ni-S	7	8.90	51.71	26.26	1.89	6.01	29.89	19.2989	18.4722	0.8267	0.983	1.2444	1.2786
1	6-20-90	Ni-S	8	8.90	51.20	26.18	1.86	5.99	29.47	18.3440	17.5218	0.8222	0.983	1.2554	
1	6-20-90	Ni-S	9	8.90	51.52	26.14	1.85	6.09	29.58	18.5259	17.6477	0.8782	0.983	1.3361	
1	6-20-90	Ni-P	1	8.90	51.05	26.08	1.77	5.94	29.13	16.9569	16.9357	0.0212	1.000	0.0322	0.0360
1	6-20-90	Ni-P	2	8.90	51.15	26.20	1.76	6.09	29.28	17.3143	17.2890	0.0253	1.000	0.0382	
1	6-20-90	Ni-P	3	8.90	51.07	25.98	1.79	6.07	29.06	17.2040	17.1794	0.0246	1.000	0.0375	
1	6-21-90	Ni-P	4	8.90	50.93	25.90	1.77	5.94	28.88	17.0258	17.0008	0.0250	1.000	0.0383	0.0405
1	6-21-90	Ni-P	5	8.90	51.33	25.94	1.77	6.00	29.13	17.1694	17.1407	0.0287	1.000	0.0436	
1	6-21-90	Ni-P	6	8.90	51.51	26.02	1.75	6.04	29.28	16.9687	16.9425	0.0262	1.000	0.0396	
1a	6-21-90	Ni-P	7	8.90	51.05	25.95	1.73	5.96	28.93	16.8198	16.7970	0.0228	1.000	0.0349	0.0525
1a	6-21-90	Ni-P	8	8.90	50.95	25.99	1.77	5.99	28.98	16.8380	16.7847	0.0533	1.000	0.0814	
1a	6-21-90	Ni-P	9	8.90	51.24	26.04	1.76	5.98	29.17	17.2677	17.2404	0.0273	1.000	0.0414	
2	6-22-90	Ni-S	1	8.90	51.32	26.25	1.86	5.95	29.62	18.7375	18.1303	0.6072	1.000	0.9068	0.8562
2	6-22-90	Ni-S	2	8.90	51.61	26.22	1.81	6.00	29.66	19.1740	18.5777	0.5963	1.000	0.8894	
2	6-22-90	Ni-S	3	8.90	51.43	26.20	1.81	5.99	29.54	18.0686	17.5528	0.5158	1.000	0.7725	
3	6-25-90	Ni-S	4	8.90	51.57	26.44	1.94	6.26	30.06	19.4938	19.1782	0.3156	1.033	0.4496	0.5462
3	6-25-90	Ni-S	5	8.90	51.63	26.04	1.79	6.22	29.41	17.9042	17.4001	0.5041	1.033	0.7340	
3	6-25-90	Ni-S	6	8.90	52.08	26.37	1.91	6.05	30.25	19.3426	19.0212	0.3214	1.033	0.4550	
4	6-26-90	Ni-S	7	8.90	51.62	26.17	1.84	6.10	29.65	18.4713	17.8338	0.6375	1.000	0.9512	1.0428
4	6-26-90	Ni-S	8	8.90	51.06	26.14	1.80	6.08	29.24	17.5210	16.7608	0.7602	1.000	1.1502	
4	6-26-90	Ni-S	9	8.90	51.47	26.12	1.79	6.21	29.41	17.6460	16.9633	0.6827	1.000	1.0269	
6	6-26-90	Ni-S	10	8.90	51.61	26.35	1.95	5.88	30.06	20.2621	20.1315	0.1306	1.000	0.1922	0.1843
6	6-26-90	Ni-S	11	8.90	51.91	26.70	2.15	5.80	30.96	21.5455	21.4141	0.1314	1.000	0.1877	
6	6-26-90	Ni-S	12	8.90	51.71	26.36	1.93	5.94	30.08	19.9509	19.8333	0.1176	1.000	0.1729	
7	6-27-90	Ni-S	13	8.90	51.40	26.22	1.87	5.91	29.66	18.7464	18.5997	0.1467	1.000	0.2188	0.2108
7	6-27-90	Ni-S	14	8.90	51.39	26.17	1.84	5.98	29.54	18.4245	18.2962	0.1283	1.000	0.1922	
7	6-27-90	Ni-S	15	8.90	51.46	26.33	1.93	5.94	29.91	19.3789	19.2292	0.1497	1.000	0.2214	
5	6-28-90	Ni-S	16	8.90	51.79	26.12	1.81	5.96	29.66	18.1253	17.9718	0.1535	1.000	0.2290	0.2087
5	6-28-90	Ni-S	17	8.90	51.56	26.30	1.99	5.94	30.04	19.3948	19.2749	0.1199	1.000	0.1766	
5	6-28-90	Ni-S	18	8.90	51.44	26.13	1.87	5.79	29.60	18.8133	18.6658	0.1475	1.000	0.2205	
5	6-28-90	C4340	47	7.84	50.92	26.26	1.65	6.37	28.98	15.5686	15.5682	0.0004	1.000	0.0007	
5	6-28-90	Ni-P	1	8.90	51.07	26.09	1.80	5.98	29.20	16.9335	16.9104	0.0231	1.000	0.0350	0.0372
5	6-28-90	Ni-P	2	8.90	51.18	26.16	1.79	6.09	29.31	17.2878	17.2613	0.0265	1.000	0.0400	
5	6-28-90	Ni-P	3	8.90	51.13	25.99	1.81	6.08	29.13	17.1785	17.1543	0.0242	1.000	0.0367	
2	6-29-90	Ni-P	4	8.90	50.92	25.93	1.80	6.01	28.95	16.9999	16.9709	0.0290	1.050	0.0422	0.0447
2	6-29-90	Ni-P	5	8.90	51.34	25.93	1.80	6.03	29.18	17.1388	17.1041	0.0347	1.050	0.0501	
2	6-29-90	Ni-P	6	8.90	51.54	26.03	1.77	6.09	29.33	16.9409	16.9109	0.0300	1.083	0.0418	
6	7-2-90	Ni-P	7	8.90	51.00	25.98	1.76	6.10	28.96	16.7903	16.7758	0.0145	1.033	0.0214	0.0277
6	7-2-90	Ni-P	8	8.90	51.02	25.75	1.77	6.07	28.75	16.7833	16.7567	0.0266	1.033	0.0396	
6	7-2-90	Ni-P	9	8.90	51.28	26.06	1.79	6.09	29.26	17.2393	17.2242	0.0151	1.033	0.0221	
7	7-2-90	Ni-P	10	8.90	51.21	26.03	1.79	6.12	29.18	17.1002	17.0896	0.0106	1.000	0.0161	0.0164
7	7-2-90	Ni-P	11	8.90	50.99	25.97	1.77	6.14	28.96	17.0856	17.0747	0.0109	1.000	0.0167	
7	7-2-90	Ni-P	12	8.90	51.46	25.93	1.79	6.13	29.21	17.2546	17.2438	0.0108	1.000	0.0164	

Stripper Solution	Test Date	Coupon Material	Coupon #	Density (g/cm3)	Unmasked Dimensions in mm length	width	thick	hole diam. (mm)	Surface Area (cm2)	Initial Mass (grams)	Final Mass (grams)	Mass Loss (grams)	Total Time (hrs)	Stripping Rate (mil/hr)	Average S.R. (mil/hr)
3	7-3-90	Ni-P	13	8.90	51.37	25.94	1.80	6.10	29.19	16.9887	16.9647	0.0240	0.983	0.0370	0.0444
3	7-3-90	Ni-P	14	8.90	51.26	25.92	1.80	6.05	29.12	17.1694	17.1472	0.0222	0.983	0.0343	
3	7-3-90	Ni-P	15	8.90	51.18	26.09	1.81	6.15	29.26	17.5362	17.4959	0.0403	0.983	0.0620	
4	7-5-90	Ni-P	16	8.90	51.26	26.07	1.84	6.12	29.34	17.6524	17.6191	0.0333	1.000	0.0502	0.0381
4	7-5-90	Ni-P	17	8.90	50.82	25.97	1.79	6.05	28.91	16.8700	16.8492	0.0208	1.000	0.0318	
4	7-5-90	Ni-P	18	8.90	51.42	25.95	1.75	6.09	29.15	16.7013	16.6800	0.0213	1.000	0.0323	
8	7-3-90	Ni-S	19	8.90	51.81	26.42	1.96	5.88	30.26	20.1682	19.8989	0.2693	1.000	0.3937	0.3628
8	7-3-90	Ni-S	20	8.90	51.86	26.14	1.90	5.95	29.88	19.0115	18.7799	0.2316	1.000	0.3429	
8	7-3-90	Ni-S	21	8.90	51.21	26.16	1.85	5.95	29.45	19.0359	18.8018	0.2341	1.000	0.3517	
8	7-3-90	Ni-P	19	8.90	50.40	26.17	1.77	6.10	28.84	16.9070	16.8949	0.0121	1.000	0.0186	0.0207
8	7-3-90	Ni-P	20	8.90	51.15	26.09	1.79	6.05	29.22	17.0957	17.0804	0.0153	1.000	0.0232	
8	7-3-90	Ni-P	21	8.90	51.37	25.94	1.79	6.07	29.18	17.2592	17.2458	0.0134	1.000	0.0203	
9	7-10-90	Ni-S	22	8.90	52.31	26.51	2.00	6.09	30.69	20.4896	20.4766	0.0130	1.050	0.0178	0.0143
9	7-10-90	Ni-S	23	8.90	51.32	26.37	1.95	5.93	29.91	20.1034	20.0941	0.0093	1.050	0.0131	
9	7-10-90	Ni-S	24	8.90	51.86	26.54	2.01	5.86	30.51	20.3205	20.3118	0.0087	1.050	0.0120	
9	7-10-90	Ni-P	22	8.90	51.29	25.99	1.80	6.05	29.21	17.1609	17.1551	0.0058	1.000	0.0088	0.0092
9	7-10-90	Ni-P	23	8.90	50.78	25.99	1.80	6.08	28.92	17.0870	17.0801	0.0069	1.000	0.0106	
9	7-10-90	Ni-P	24	8.90	50.96	25.98	1.76	6.14	28.93	16.7945	16.7890	0.0055	1.000	0.0084	
10	7-11-90	Ni-S	25	8.90	51.52	26.37	1.95	5.96	30.02	19.4679	19.4670	0.0009	1.000	0.0013	0.0021
10	7-11-90	Ni-S	26	8.90	51.72	26.30	1.94	5.94	30.04	19.9225	19.9205	0.0020	1.000	0.0029	
11	7-11-90	Ni-S	27	8.90	51.72	26.20	1.94	6.01	29.92	17.0869	17.0843	0.0026	1.000	0.0038	0.0035
10	7-11-90	Ni-P	25	8.90	51.35	26.02	1.79	6.12	29.25	17.1289	17.1278	0.0011	1.000	0.0017	0.0015
11	7-11-90	Ni-P	26	8.90	51.09	26.04	1.80	6.09	29.15	18.8864	18.8838	0.0026	1.000	0.0039	0.0035
14	7-17-90	Ni-S	10	8.90	51.89	26.37	1.91	5.93	30.16	20.1315	20.1139	0.0176	1.033	0.0250	0.0250
13	7-17-90	Ni-S	11	8.90	51.90	26.70	2.13	5.85	30.92	21.4140	20.7329	0.6811	1.067	0.9136	0.9136
12	7-17-90	Ni-S	12	8.90	51.93	26.32	1.89	6.00	30.08	19.8332	19.8285	0.0047	1.050	0.0066	0.0066
15	7-18-90	Ni-S	13	8.90	51.54	26.22	1.86	5.95	29.71	18.5993	18.5689	0.0304	1.017	0.0445	0.0445
16	7-18-90	Ni-S	14	8.90	51.26	26.20	1.84	6.00	29.49	18.2955	18.2775	0.0180	1.000	0.0270	0.0270
17	7-18-90	Ni-S	15	8.90	51.43	26.32	1.89	5.95	29.81	19.2288	19.1980	0.0308	1.000	0.0457	0.0457
18	7-18-90	Ni-S	19	8.90	51.72	26.35	1.99	5.93	30.18	19.8989	19.8903	0.0086	1.000	0.0126	0.0126
19	7-18-90	Ni-S	20	8.90	51.73	26.14	1.85	6.00	29.71	18.7793	18.7764	0.0029	1.000	0.0043	0.0043
13	7-18-90	Ni-P	27	8.90	51.71	26.04	1.77	6.10	29.44	16.7964	16.4411	0.3553	1.000	0.5339	0.5339
20	7-19-90	Ni-S	28	8.90	51.09	26.23	1.85	5.95	29.45	18.5072	17.6161	0.8911	0.983	1.3611	1.4724
20	7-19-90	Ni-S	29	8.90	51.98	26.50	1.91	5.90	30.35	20.4258	19.3679	1.0579	1.000	1.5417	
20	7-19-90	Ni-S	30	8.90	51.42	26.20	1.87	5.94	29.64	19.4978	18.4830	1.0148	1.000	1.5144	
20	7-19-90	Ni-P	28	8.90	51.38	25.98	1.76	6.42	29.13	16.9736	16.5108	0.4628	1.050	0.6694	0.6623
20	7-19-90	Ni-P	29	8.90	51.37	26.06	1.80	6.10	29.32	17.3290	16.8854	0.4436	1.050	0.6374	
20	7-19-90	Ni-P	30	8.90	51.25	26.00	1.80	6.12	29.19	17.1598	16.6885	0.4713	1.050	0.6803	
20	7-20-90	Ni-P	28	8.90	51.21	25.92	1.73	6.48	28.91	16.5053	16.1919	0.3134	1.000	0.4796	0.4689
20	7-20-90	Ni-P	29	8.90	51.29	25.97	1.73	6.23	29.04	16.8809	16.5794	0.3015	1.000	0.4592	
20	7-20-90	Ni-P	30	8.90	51.18	25.94	1.76	6.21	29.00	16.6811	16.3744	0.3067	1.000	0.4678	
21	7-24-90	Ni-P	31	8.90	50.93	25.98	1.76	6.18	28.91	16.9233	16.6973	0.2260	1.017	0.3401	0.3665
21	7-24-90	Ni-P	32	8.90	50.73	26.06	1.76	6.13	28.89	16.7379	16.5090	0.2289	1.017	0.3447	
21	7-24-90	Ni-P	33	8.90	51.44	25.99	1.77	6.42	29.19	17.0100	16.7318	0.2782	1.017	0.4147	
21	7-24-90	Ni-S	31	8.90	50.86	26.25	1.85	6.04	29.33	18.1514	17.6819	0.4695	0.983	0.7200	0.7247
21	7-24-90	Ni-S	32	8.90	51.37	26.25	1.89	6.00	29.69	19.2668	18.7942	0.4726	0.983	0.7160	
21	7-24-90	Ni-S	33	8.90	51.80	26.37	1.93	6.28	30.10	19.5778	19.0839	0.4939	0.983	0.7382	
22	7-24-90	Ni-S	34	8.90	51.35	26.17	1.85	6.00	29.53	18.6752	18.6057	0.0695	0.967	0.1077	0.1208
22	7-24-90	Ni-S	35	8.90	51.82	26.17	1.82	6.17	29.72	18.3243	18.2301	0.0942	0.967	0.1451	

Stripper Solution	Test Date	Coupon Material	Coupon #	Density (g/cm3)	Unmasked Dimensions in mm			hole diam. (mm)	Surface Area (cm2)	Initial Mass (grams)	Final Mass (grams)	Mass Loss (grams)	Total Time (hrs)	Stripping Rate (mil/hr)	Average S.R. (mil/hr)
					length	width	thick								
22	7-24-90	Ni-S	36	8.90	51.81	26.18	1.84	6.05	29.77	18.5410	18.4697	0.0713	0.967	0.1096	
23	9-5-90	Ni-S	46	8.90	51.52	26.25	1.91	5.90	29.83	19.6727	17.8177	1.8550	1.000	2.7512	2.7837
23	9-5-90	Ni-S	47	8.90	51.14	26.22	1.85	5.94	29.47	18.3057	16.3801	1.9256	1.000	2.8903	
23	9-5-90	Ni-S	48	8.90	51.60	25.74	1.87	5.90	29.26	18.7898	16.9977	1.7921	1.000	2.7097	
23	9-5-90	Ni-P	46	8.90	51.19	25.99	1.72	5.94	29.03	17.2284	17.2108	0.0176	1.000	0.0268	0.0275
23	9-5-90	Ni-P	47	8.90	51.09	26.07	1.75	5.95	29.11	16.7200	16.7009	0.0191	1.000	0.0290	
23	9-5-90	Ni-P	48	8.90	50.91	26.25	1.77	5.91	29.24	16.8252	16.8076	0.0176	1.000	0.0266	
1	7-25-90	C4340	46	7.84	50.78	25.95	1.66	6.45	28.59	15.1365	15.1361	0.0004	24.050	0.0000	0.0000
1	7-25-90	410	49	7.70	51.00	25.60	1.56	6.47	28.16	13.9889	13.9885	0.0004	24.050	0.0000	0.0000
20	7-25-90	C4340	47	7.84	50.92	26.28	1.65	6.46	28.99	15.5682	15.3113	0.2569	24.050	0.0185	0.0185
20	7-25-90	410	50	7.70	51.65	25.47	1.56	6.50	28.37	14.2125	13.8673	0.3452	24.050	0.0259	0.0259

APPENDIX O

GENERIC NICKEL STRIPPER DEVELOPMENT: ELECTROCHEMICAL TEST DATA

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POTENTIODYNAMIC ANODIC POLARIZATION TESTS WITH NICKEL ELECTRODE

Solution	Solution Composition	Concentration	Function	E_{oc} (mV)	Comments
58	Ethylenediamine	3.7 M	Complexation	-760	
	Nitric Acid	1.0 M	pH/Oxidation		
	Sodium Nitrate	0.6 M	Oxidation		
	Sodium Nitrite	1.0 M	Activation/Inhibition		
56	Ethylenediamine	3.7 M	Complexation	-750	
	Nitric Acid	1.0 M	pH/Oxidation		
	Ammonium Nitrate	0.6 M	pH/Oxidation		
	Nitromethane	0.9 M	Inhibition/Activation		
1	Ethylenediamine	3.7 M	Complexation	-710	Exothermic reaction between ingredients. Color reddens slowly.
	Nitromethane	2.8 M	Activation/Inhibition		
2	Ethylenediamine	3.7 M	Complexation	-700	Solution stirred
	Sodium Nitrite	2.2 M	Activation/Inhibition		
3	Ammonium Thiocyanate	1.0 M	Activation	-650	
	Sodium Hydroxide	1.0 M	pH		
54	Ethylenediamine	3.7 M	Complexation	-610	
	Nitric Acid	1.0 M	pH/Oxidation		
	Sodium Nitrate	0.6 M	Oxidation		
	Sodium Thiosulfate	0.05 M	Activation		
	Sodium *m*-nitrobenzensulfonate	0.7 M	Inhibition		
4	CLEPO 204-N	neat	Formulation	-580	
60	Ammonium Thiocyanate	0.1 M	Activation	-580	
	Sodium Hydroxide	1.0 M	pH		
	Sodium Nitrite	1.0 M	Inhibition		

Solution	Solution Composition	Concentration	Function	E_{oc} (mV)	Comments
55	Ethylenediamine	3.7 M	Complexation	-580	
	Nitric Acid	1.0 M	pH/Oxidation		
	Sodium Nitrate	0.6 M	Oxidation		
	Thiourea	1.0 M	Activation		
	Sodium *m*-nitrobenzensulfonate	0.7 M	Inhibition		
57	Ethylenediamine	3.7 M	Complexation	-580	
	Nitric Acid	1.0 M	pH/Oxidation		
	Sodium Nitrate	0.6 M	Oxidation		
	Sodium Thiosulfate	1.0 M	Activation		
	Sodium *m*-nitrobenzenesulfonate	0.7 M	Inhibition		
5	Ethylenediamine	3.9 M	Complexation	-560	
	Nitric Acid	2.1 M	pH control		
53	Ethylenediamine	3.7 M	Complexation	-550	
	Nitric Acid	1.0 M	pH/Oxidation		
	Sodium Nitrate	0.6 M	Oxidation		
	Ammonium Thiocyanate	0.05 M	Activation		
	Sodium *m*-nitrobenzensulfonate	0.7 M	Inhibition		
6	Ethylenediamine	4.5 M	Complexation	-500	
61	Glycine	2.0 M	Complexation	-500	
	Sodium Nitrate	0.6 M	Oxidation		
	Ammonium Thiocyanate	0.05 M	Activation		
	Sodium *m*-nitrobenzenesulfonate	0.7 M	Inhibition		
7	m-Pyrol (GAF)	2.6 M	Complexation	-490	Wide scan range
	Sodium *m*-nitrobenzensulfonate	0.5 M	Inhibition/ Activation	-330	Narrow scan range
52	Ethylenediamine	3.7 M	Complexation	-490	
	Nitric Acid	1.0 M	pH/Oxidation		
	Sodium Nitrate	0.6 M	Oxidation		
	Sodium *m*-nitrobenzensulfonate	0.7 M	Inhibition		

Solution	Solution Composition	Concentration	Function	E_{oc} (mV)	Comments
59	Ammonium Thiocyanate	1.0 M	Activation/ Complexation	-450	
	Sodium *m*-nitrobenzenesulfonate	0.7 M	Inhibition		
8	Ethylenediamine	3.7 M	Complexation	-440	
	Ammonium Nitrate	1.9 M	pH/Oxidation		
	Sodium *m*-nitrobenzenesulfonate	0.7 M	Inhibition		
9	Ethylenediamine	1.5 M	Complexation	-430	
	Nitric Acid	0.8 M	pH/Oxidation		
	Sodium *m*-nitrobenzenesulfonate	0.2 M	Inhibition		
10	Ethylenediamine	3.7 M	Complexation	-430	
	Acetic Acid (glacial)	0.9 M	pH		
	Sodium *m*-nitrobenzenesulfonate	0.7 M	Inhibition		
	Ammonium Nitrate	1.2 M	pH/Oxidation		
11	Ethanolamine	4.1 M	Complexation	-410	
	Ammonium Nitrate	1.9 M	pH/Oxidation		
	Sodium *m*-nitrobenzenesulfonate	0.7 M	Inhibition		
12	Glycine	0.5 M	Complexation	-380	
	Sodium Hydroxide	0.5 M	pH		
	Sodium Nitrite	0.2 M	Oxidation/ Inhibition		
	Sodium *m*-nitrobenzensulfonate	0.5 M	Inhibition		
13	Glycine	0.5 M	Complexation	-370	
	Sodium Hydroxide	0.5 M	pH		
	Ammonium Nitrate	0.1 M	pH/Oxidation		
	Sodium *m*-nitrobenzensulfonate	0.1 M	Inhibition		
14	CLEPO-204		Formulation	-370	
15	Ethylenediamine	1.5 M	Complexation	-340	
	Potassium Nitrate	0.1 M	Oxidation		
16	Ethylenediaminetetraacetic acid	0.1 M	Complexation	-320	pH adjust to 7.5 with sodium hydroxide

Solution	Solution Composition	Concen-tration	Function	E_{oc} (mV)	Comments
17	Glycine	0.5 M	Complexation	-310	
	Sodium Hydroxide	0.5 M	pH		
	Calcium Nitrate	0.1 M	Oxidation		
	Sodium *m*-nitrobenzenesulfonate	0.1 M	Inhibition		
18	Cysteine Hydrochloride	0.1 M	Complexation	-310	
	Sodium Hydroxide	0.2 M	pH		
19	Cystine	0.5 M	Complexation	-300	
	Sodium Hydroxide	1.0 M	pH		
20	Ethylenediamine	1.35 M	Complexation	-290	
	Ammonium Nitrate	0.1 M	Oxidation		
21	Guanidine Hydrochloride	0.5 M	Complexation	-270	
	Sodium Hydroxide	0.5 M	pH		
22	Sodium Bicarbonate	0.1 M	pH/ Complexation	-270	
23	Diammonium Citrate	1.0 M	Complexation	-270	
24	Sodium Fluoride	0.5 M	Complexation	-260	
25	Glycine	0.5 M	Complexation	-250	
	Sodium Hydroxide	0.5 M	pH		
	Sodium Nitrite	0.5 M	Oxidation/ Inhibition		
26	Glycine	0.05 M	Complexation	-250	
	Sodium Hydroxide	0.05 M	pH		
27	Ethylenediamine	1.5 M	Complexation	-250	
28	Glycine	0.5 M	Complexation	-250	Solution stirred
	Sodium Hydroxide	0.5 M	pH		
	Calcium Nitrate	0.1 M	Oxidation		
	Sodium *m*-nitrobenzenesulfonate	0.1 M	Inhibition		
29	Acetic Acid	5.0 M	Complexation	-230	

Solution	Solution Composition	Concen-tration	Function	E_{oc} (mV)	Comments
30	Methionine	1.0 M	Complexation	-180	pH = 10.66
31	Sodium Dodecylsulfate (SDS)	0.2 M	Complexation	-170	
32	Aminomethanesulfonic Acid	1.0 M	Complexation	-160	
	Sodium Hydroxide	1.0 M	pH		
33	Thiourea	0.05 M	Inhibition/ Complexation	-140	
34	Sodium *m*-nitrobenzenesulfonate	0.1 M	Inhibition	-140	
35	Aminomethanesulfonic Acid	0.1 M	Complexation	-130	
	Sodium Hydroxide	0.1 M	pH		
	Potassium Persulfate	0.05 M	Oxidation		
36	Guanidine Hydrochloride	0.5 M	Complexation	-130	
	Sodium Hydroxide	0.5 M	pH		
	Hydrogen Peroxide	0.1 M	Oxidation		
37	Triton X-100	10% (v)	Complexation	-110	
38	Acetic Acid	5.0 M	Complexation	-94	
39	Potassium Nitrate	0.1 M	Oxidation/ Complexation	-85	
	trans-Cinnamaldehyde	1 drop	Inhibition		
40	Sodium Dodecylsulfate	0.2 M	Complexation	-75	
	Potassium Persulfate	0.05 M	Oxidation		
41	Potassium Persulfate	0.15 M	Oxidation/ Complexation	-62	
42	Potassium Persulfate	0.15 M	Oxidation/ Complexation	-36	
	Triton X-100	1 drop	Activation		
	trans-Cinnamaldehyde	2 drops	Inhibition		

Solution	Solution Composition	Concen-tration	Function	E_{oc} (mV)	Comments
43	Ethylenediamine	1.0 M	Complexation	-20	
	Sodium *m*-nitrobenzenesulfonate	0.1 M	Inhibition		
	Hydrogen Peroxide	0.1 M	Oxidation		
44	Glycine	0.5 M	Complexation	+24	
	Sodium Hydroxide	0.5 M	pH		
	Ammonium Nitrate	0.1 M	Oxidation		
	Sodium *m*-nitrobenzensulfonate	0.1 M	Inhibition		
45	Potassium Persulfate	0.1 M	Oxidation/ Complexation	+30	
	Sodium *m*-nitrobenzenesulfonate	0.1 M	Inhibition		
46	Sodium Dodecylsulfate	0.5 M	Activation	+36	
	Hydrogen Peroxide	0.5 M	Oxidation		
47	Ethylendiamine	1.5 M	Complexation	+37	
	Potassium Persulfate	0.1 M	Oxidation		
48	Glycine	0.5 M	Complexation	+54	
	Sodium Hydroxide	0.5 M	pH		
	Hydrogen Peroxide	0.5 M	Oxidation		
49	Glycine	0.1 M	Complexation	+58	
	Sodium Hydroxide	0.1 M	pH		
	Sodium Nitrite	0.5 M	Inhibition		
	Hydrogen Peroxide	0.1 M	Oxidation		
50	Nitric Acid	1.2 M	Oxidation/ Complexation	+60	
	Triton X-100	5% (v)	Activation		
	trans-Cinnamaldehyde	10% (v)	Inhibition		
51	Hydrogen Peroxide	1.0 M	Oxidation/ Inhibition	+210	

POTENTIODYNAMIC ANODIC POLARIZATION TESTS WITH C9310 STEEL ELECTRODE

Solution	Solution Composition	Concentration	Function	E_{0c} (mV)	Comments
28	Hydrogen Peroxide	1.0 M	Oxidation	+140	
27	Thiourea	0.05 M	Inhibition	-130	
26	Ethylenediamine	1.0 M	Complexation	-160	
	Hydrogen Peroxide	0.1 M	Oxidation		
	Sodium *m*-nitrobenzenesulfonate	0.1 M	Inhibition		
25	Sodium *m*-nitrobenzenesulfonate	0.1 M	Inhibition	-240	
22	Ethanolamine	4.1 M	Complexation	-320	
	Ammonium Nitrate	1.9 M	pH/Oxidation		
	Sodium *m*-nitrobenzenesulfonate	0.7 M	Inhibition		
23	Glycine	1.0 M	Complexation	-320	
	Sodium Hydroxide	1.0 M	pH		
	Ammonium Nitrate	1.2 M	pH/Oxidation		
	Sodium *m*-nitrobenzenesulfonate	0.5 M	Inhibition		
24	Sodium Bicarbonate	0.1 M	pH	-320	
21	Ethylenediamine	3.7 M	Complexation	-340	
	Acetic Acid	0.9 M	pH		
	Ammonium Nitrate	1.2 M	pH/Oxidation		
	Sodium *m*-nitrobenzenesulfonate	0.7 M	Inhibition		
20	Ethylenediamine	3.7 M	Complexation	-350	
	Acetic Acid	0.9 M	pH		
	Sodium *m*-nitrobenzenesulfonate	0.7 M	Inhibition		
19	Ethylenediamine	3.7 M	Complexation	-350	
	Ammonium Nitrate	1.9 M	pH/Oxidation		
	Sodium *m*-nitrobenzenesulfonate	0.7 M	Inhibition		

Solution	Solution Composition	Concentration	Function	E_{oc} (mV)	Comments
17	Ethylenediamine Nitric Acid Sodium *m*-nitrobenzenesulfonate	1.5 M 0.8 M 0.2 M	Complexation pH Inhibition	-360	
18	Ethylenediamine Nitric Acid Ammonium Nitrate Sodium *m*-nitrobenzenesulfonate	3.7 M 1.0 M 0.6 M 0.7 M	Complexation pH pH/Oxidation Inhibition	-360	
16	Ammonium Thiocyanate Sodium Hydroxide	1.0 M 1.0 M	Complexation pH	-370	
15	Glycine Sodium Hydroxide Sodium Nitrite Sodium *m*-nitrobenzenesulfonate	0.5 M 0.5 M 0.2 M 0.2 M	Complexation pH Inhibition Inhibition	-380	
14	CLEPO 204		Formulation	-390	
13	Potassium Nitrate	0.1 M	Oxidation/ Complexation	-390	
12	Ethylenediamine	1.5 M	Complexation	-400	
11	Sodium Iodide Sodium Hydroxide	0.1 M 0.09 M	Complexation pH	-400	
9	Methionine Sodium Hydroxide	1.0 M 1.0 M	Complexation pH	-410	pH adjust to 10.66
10	Sodium Iodide Ethylenediamine	0.1 M 1.5 M	Complexation Complexation	-410	
8	Sodium Iodide	1.0 M	Complexation	-430	
7	Ammonium Thiocyanate Sodium Hydroxide Thiourea	1.0 M 1.0 M 1.0 mM	Complexation pH Inhibition	-440	

Solution	Solution Composition	Concentration	Function	E_{oc} (mV)	Comments
6	Potassium Persulfate	0.15 M	Oxidation/ Complexation	-450	
5	CLEPO 204-N	neat	Formulation	-460	
4	Potassium Persulfate	0.15 M	Oxidation/ Complexation	-490	
	Triton X-100	1% (v)	Activation		
	trans-Cinnamaldehyde	2% (v)	Inhibition		
3	Potassium Sulfate	0.1 M	Complexation	-530	
2	Sodium Thiosulfate	1.0 M	Complexation	-550	
1	Glycine	0.5 M	Complexation	-560	
	Sodium Hydroxide	0.5 M	pH		

TAFEL PLOT CALCULATIONS FOR THEORETICAL STRIPPING RATES

Solution	Solution Composition	Concentration	Function	Stripping Rate-mil/yr	Comments
9	Ethylenediamine	3.7 M	Complexation	5100 (Ni)	
	Nitric Acid	1.0 M	Oxidation/pH	0.21 (9310)	
	Sodium Nitrate	0.6 M	Oxidation		
	Sodium *m*-nitrobenzenesulfonate	0.67M	Inhibition/ Activation		
	Thiourea	1.0 M	Activation		
10	Ethylenediamine	3.7 M	Complexation	4900 (Ni)	
	Nitric Acid	1.0 M	Oxidation/pH	0.17 (9310)	
	Sodium Nitrate	0.6 M	Oxidation		
	Sodium *m*-nitrobenzenesulfonate	0.67M	Inhibition/ Activation		
	Ammonium Thiocyanate	0.05M	Activation		
11	Ethylenediamine	3.7 M	Complexation	2900 (Ni)	
	Nitric Acid	1.0 M	Oxidation/pH		
	Sodium Nitrate	0.6 M	Oxidation		
	Sodium *m*-nitrobenzenesulfonate	0.67M	Inhibition/ Activation		
1	Ammonium Thiocyanate	1.0 M	Activation/ Complexation	2200 (Ni) 340 (Ni)	Scan cathodic to anodic Scan anodic to cathodic
	Sodium Hydroxide	1.0 M	pH		
	Sodium *m*-nitrobenzenesulfonate	0.5 M	Inhibition		
2	CLEPO 204	neat	Formulation	1300 (Ni)	
3	Ethylenediamine	1.5 M	Complexation	820 (Ni)	
	Nitric Acid	0.8 M	pH		
	Sodium *m*-nitrobenzenesulfonate	0.2 M	Inhibition		
12	Ammonium Thiocyanate	1.0 M		800 (Ni)	
	Sodium *m*-nitrobenzenesulfonate	0.67M		0.21 (9310)	

Solution	Solution Composition	Concentration	Function	Stripping Rate-mil/yr	Comments
13	Ethylenediamine	3.7 M	Complexation	320 (Ni)	
	Nitric Acid	1.0 M	Oxidation/pH		
	Sodium Nitrate	0.6 M	Oxidation		
	Nitromethane	0.90M	Inhibition/ Activation		
4	Ethylenediamine	3.7 M	Complexation	160 (Ni)	
	Nitromethane	2.8 M	Inhibition/ Activation		
14	Ethylendiamine	3.7 M	Complexation	62 (Ni)	
	Sodium Nitrate	0.60M	Oxidation		
	Sodium Nitrite	1.0 M	Inhibition		
	Nitric Acid	1.0 M	Oxidation/pH		
5	Guanidine Hydrochloride	0.5 M	Complexation	45 (Ni)	Solution stirred
	Sodium Hydroxide	0.5 M	pH		
	Hydrogen Peroxide	0.1 M	Oxidizer		
16	Ethylenediamine	3.7 M	Complexation	25 (Ni)	
	Nitric Acid	1.0 M	Oxidation/pH	0.33 (9310)	
	Sodium Nitrate	0.6 M	Oxidation		
	Sodium *m*-nitrobenzenesulfonate	0.67M	Inhibition/ Activation		
	Sodium Thiosulfate	0.05M	Activation		
17	Glycine	2.0 M	Complexation	20 (Ni)	
	Sodium Nitrate	0.6 M	Oxidation		
	Sodium *m*-nitrobenzenesulfonate	0.67M	Inhibition/ Activation		
	Ammonium Thiocyanate	0.05M	Activation		
6	Ethylenediamine	3.7 M	Complexation	14 (Ni)	
	Sodium Nitrite	2.2 M	Inhibition/ Activation		
7	Ethylenediaminetetraacetic Acid	0.1 M	Complexation	1.1 (Ni)	pH adjusted to 7.5

Solution	Solution Composition	Concen-tration	Function	Stripping Rate-mil/yr	Comments
8	m-Pyrol (GAF)	25% V	Complexation	1.1 (Ni)	Scan cathodic to anodic
	Sodium *m*-nitrobenzenesulfonate	0.5 M	Inhibition/ Activation	0.24 (Ni)	Scan anodic to cathodic

DIRECT ZERO-CURRENT POTENTIAL MEASUREMENTS (E_{0c})

Solution	Solution Composition	Concen-tration	Electrode Material	E_{0c} (V)	Comments
1	Ammonium Nitrate	1.0 M	Pt	0.51	
			Ag	0.38	
			Ni	0.25	
			Cu	0.26	
			FBz	0.13	
			17-4PH	0.08	
			9310	-0.07	
			410SS	0.11	
2	Sodium Thiosulfate	1.0 M	Pt	0.24	
			Ag	-0.16	
			Ni	0.19	
			Cu	-0.48	
			FBz	-0.33	
			17-4PH	-0.08	
			9310	-0.30	
			410SS	-0.05	
3	Sodium Hydroxide	0.1 M	Pt	0.24	
			Ag	-0.01	
			Ni	-0.09	
			Cu	-0.14	
			FBz	-0.16	
			17-4PH	-0.06	
			9310	-0.10	
			410SS	-0.05	

Solution	Solution Composition	Concentration	Electrode Material	E_{oc} (V)	Comments
4	Citric Acid	10 %	Pt	0.77	410SS evolved gas
			Ag	0.02	
			Ni	-0.09	
			Cu	0.23	
			FBz	0.20	
			17-4PH	0.17	
			9310	-0.24	
			410SS	-0.30	
5	Citric Acid	0.1 M	Pt	0.48	
	Sodium Hydroxide	0.3 M	Ag	0.05	
			Ni	-0.10	
			Cu	0.07	
			FBz	0.01	
			17-4PH	0.03	
			9310	-0.52	
			410SS	0.02	
6	Oxalic Acid	1.0 M	Pt	0.72	410SS evolved hydrogen gas
			Ag	0.13	
			Ni	-0.03	
			Cu	0.16	
			FBz	0.15	
			17-4PH	0.13	
			9310	-0.22	
			410SS	-0.28	
7	Acetic Acid	1.0 M	Pt	0.75	
			Ag	0.14	
			Ni	0.04	
			Cu	0.24	
			FBz	0.22	
			17-4PH	0.20	
			9310	-0.24	
			410SS	-0.22	

Solution	Solution Composition	Concentration	Electrode Material	E_{oc} (V)	Comments
8	Sodium Bicarbonate	0.1 M	Pt	0.50	
			Ag	0.19	
			Ni	0.01	
			Cu	0.14	
			FBz	0.10	
			17-4PH	0.08	
			9310	-0.01	
			410SS	0.08	
9	Sodium Carbonate	0.1 M	Pt	0.36	
			Ag	0.20	
			Ni	0.05	
			Cu	0.09	
			FBz	0.06	
			17-4PH	0.03	
			9310	0.06	
			410SS	-0.05	
10	Sodium *m*-nitrobenzenesulfonate	0.1 M	Pt	0.40	
			Ag	0.23	
			Ni	0.06	
			Cu	0.15	
			FBz	0.13	
			17-4PH	0.05	
			9310	0.03	
			410SS	-0.01	
11	Sodium Iodide	0.1 M	Pt	0.34	
			Ag	-0.06	
			Ni	0.05	
			Cu	-0.10	
			FBz	-0.11	
			17-4PH	0.05	
			9310	-0.22	
			410SS	0.04	

Solution	Solution Composition	Concen-tration	Electrode Material	E_{oc} (V)	Comments
12	Sodium Iodide	0.1 M	Pt	0.52	
	Hydrogen Peroxide	1.0 M	Ag	-0.05	
			Ni	0.19	
			Cu	0.24	
			FBz	-0.06	
			17-4PH	0.39	
			9310	0.04	
			410SS	0.38	
13	Sodium Iodide	0.1 M	Pt	0.51	aged overnight to rid solution
	Hydrogen Peroxide	1.0 M	Ag	-0.07	of excess peroxide
			Ni	0.20	
			Cu	-0.05	
			FBz	-0.05	
			17-4PH	0.43	
			9310	-0.20	
			410SS	0.40	
14	Potassium Borate	0.05 M	Pt	0.42	
			Ag	0.21	
			Ni	0.01	
			Cu	0.15	
			FBz	0.08	
			17-4PH	-0.03	
			9310	-0.04	
			410SS	-0.02	
15	Sodium Silicate	0.1 M	Pt	0.21	
			Ag	0.20	
			Ni	-0.01	
			Cu	0.03	
			FBz	0.04	
			17-4PH	0.02	
			9310	0.04	
			410SS	-0.02	

Solution	Solution Composition	Concen-tration	Electrode Material	E_{oc} (V)	Comments
16	Potassium Hydrogen Phthalate	0.1 M	Pt	0.54	
	Sodium Hydroxide	0.1 M	Ag	0.22	
			Ni	0.08	
			Cu	0.17	
			FBz	0.14	
			17-4PH	0.12	
			9310	-0.32	
			410SS	0.11	
17	Sodium Sulfite	0.1 M	Pt	0.27	
			Ag	0.14	
			Ni	-0.11	
			Cu	-0.11	
			FBz	-0.14	
			17-4PH	-0.14	
			9310	-0.10	
			410SS	-0.14	
18	Ammonium Thiocyanate	0.1 M	Pt	0.32	purged with air to remove all
	Sodium Hydroxide	0.1 M	Ag	0.18	traces of ammonia
			Ni	-0.20	
			Cu	-0.15	
			FBz	-0.18	
			17-4PH	-0.01	
			9310	-0.04	
			410SS	-0.02	
19	Sodium Tartrate	0.1 M	Pt	0.54	
			Ag	0.25	
			Ni	0.12	
			Cu	0.14	
			FBz	0.10	
			17-4PH	0.08	
			9310	0.07	
			410SS	0.04	

Solution	Solution Composition	Concen-tration	Electrode Material	E_{oc} (V)	Comments
20	p-Aminophenol	0.1 M	Pt	0.05	
	Sodium Hydroxide	0.1 M	Ag	0.07	
			Ni	0.05	
			Cu	0.07	
			17-4PH	0.06	
			9310	0.06	
			410SS	0.08	
21	Ethylenediamine	0.15 M	Pt	0.20	
			Ag	0.15	
			Ni	-0.30	
			Cu	-0.17	
			17-4PH	-0.07	
			9310	-0.02	
			410SS	-0.04	
22	Salicylic Acid	0.1 M	Pt	0.65	
	Sodium Hydroxide	0.1 M	Ag	0.22	
			Ni	0.01	
			Cu	0.19	
			17-4PH	0.23	
			9310	-0.13	
			410SS	0.10	
23	Sodium Nitrite	0.1 M	Pt	0.48	
			Ag	0.22	
			Ni	0.12	
			Cu	0.20	
			17-4PH	0.10	
			9310	0.12	
			410SS	0.09	

Solution	Solution Composition	Concentration	Electrode Material	E_{oc} (V)	Comments
24	Dimethylsulfoxide (DMSO)	0.28 M	Pt	0.63	
			Ag	0.21	
			Ni	0.14	
			Cu	0.20	
			17-4PH	0.20	
			9310	0.10	
			410SS	0.16	
25	Sodium Thiosulfate	1.0 M	Pt	0.23	
	Hydrogen Peroxide	2.0 M	Ag	-0.13	
			Ni	0.15	
			Cu	-0.45	
			17-4PH	-0.05	
			9310	-0.28	
			410SS	-0.05	
26	Sodium Thiosulfate	1.0 M	Pt	0.21	pH 8
	Hydrogen Peroxide	2.0 M	Ag	-0.13	
	Potassium Iodide	0.1 M	Cu	-0.46	
27	Ethylenediaminetetraacetic Acid	0.1 M	Pt	0.20	pH ≈ 10
	Sodium Hydroxide	0.4 M	Ag	0.25	
			Ni	0.07	
			Cu	-0.22	
			17-4PH	-0.02	
			9310	-0.03	
			410SS	-0.03	
28	Ammonium Thiocyanate	1.0 M	Pt	0.42	
			Ag	-0.02	
			Ni	-0.18	
			Cu	-0.30	
			17-4PH	-0.12	
			9310	-0.34	
			410SS	-0.43	

Solution	Solution Composition	Concen-tration	Electrode Material	E_{oc} (V)	Comments
29	Ammonium Thiocyanate	1.0 M	Pt	0.34	pH ≈ 8
	Sodium Hydroxide	1.0 M	Ag	-0.02	
			Ni	-0.27	
			Cu	-0.30	
			17-4PH	+0.09	
			9310	-0.38	
			410SS	-0.10	
30	Oxalic Acid	0.2 M	Pt	0.44	pH = 7.94
	Sodium Hydroxide	0.4 M	Ag	0.20	
			Ni	0.01	
			Cu	0.04	
			17-4PH	0.02	
			9310	0.04	
			410SS	-0.04	
31	Acetylacetone	1 M	Pt	0.32	pH > 9
	Sodium Hydroxide	1 M	Ag	0.19	
			Ni	0.00	
			Cu	-0.01	
			17-4PH	0.00	
			9310	-0.45	
			410SS	-0.02	
32	Nickel Sulfamate	0.5 M	Pt	0.66	pH ≈ 7. Potassium Sulfamate prepared by ppt. of Nickel ferricyanide, filtration, and testing of the supernatant.
	Potassium Ferricyanide	0.33 M	Ag	0.29	
			Ni	0.14	
			Cu	0.29	
			17-4PH	0.61	
			9310	0.60	
			410SS	0.57	

Solution	Solution Composition	Concentration	Electrode Material	E_{oc} (V)	Comments
33	Glycine	1.0 M	Pt	0.32	pH 8.50
	Sodium Hydroxide	>1.0 M	Ag	0.28	
			Ni	-0.27	
			Cu	-0.12	
			17-4PH	-0.01	
			9310	-0.48	
			410SS	0.00	
34	Glycine	1.0 M	Pt	0.48	pH 5.55
	Sodium Hydroxide	<1.0 M	Ag	0.28	
			Ni	-0.11	
			Cu	0.05	
			17-4PH	0.03	
			9310	-0.37	
			410SS	-0.02	
35	Sodium Hydroxide	1.0 M	Pt	0.15	
	Sodium Pyrophosphate	sat'd.	Ag	0.28	
			Ni	-0.02	
			Cu	-0.26	
			17-4PH	-0.24	
			9310	-0.10	
			410SS	-0.18	
36	Potassium Ferricyanide	0.1 M	Pt	0.63	Ni and Cu filmed
			Ag	0.29	9310 severely pitted
			Ni	0.54	
			Cu	0.23	
			17-4PH	0.55	
			9310	0.40	
			410SS	0.57	

Solution	Solution Composition	Concen-tration	Electrode Material	E_{oc} (V)	Comments
37	Potassium Ferrocyanide	0.1 M	Pt	0.23	
			Ag	0.20	
			Ni	0.13	
			Cu	-0.30	
			17-4PH	0.05	
			9310	0.00	
			410SS	0.01	
38	Potassium Ferricyanide	0.05 M	Pt	0.45	9310 severely pitted
	Potassium Ferrocyanide	0.05 M	Ag	0.27	
			Ni	0.43	
			Cu	0.18	
			17-4PH	0.44	
			9310	0.40	
			410SS	0.44	

APPENDIX P

BIOLOGICAL TEST DATA

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Tabulated Gas Chromatography Data for Six Hour Test

Standard Curve Data

[EN] ppm	Peak area	R_t min.
0	0	-
1.8	7.17	0.75
5.4	11.79	0.74
18	59.59	0.72
54	195.70	0.73
108	317.63	0.72
180	600.39	0.72
270	835.04	0.72
360	909.20	0.71

Regression Output:

Constant (y axis intercept) 22.93
x coefficient (slope) 2.73
R squared 0.976

Six Hour Test Data

Sample	Peak area	R_t min.	[EN] ppm
Column #1 T_i	371.71	0.73	113.2
Column #2 T_i	373.31	0.73	113.8
Column #3 T_i	0	-	0
Column #4 T_i	0	-	0
Column #5 T_i	363.51	0.75	110.2
Column #6 T_i	369.51	0.75	112.4
Column #1 T_0	317.63	0.71	93.4
Column #2 T_0	313.03	0.73	91.7
Column #3 T_0	0	-	0
Column #4 T_0	0	-	0
Column #5 T_0	315.83	0.74	92.7
Column #6 T_0	315.49	0.74	92.6
Column #1 T_6	314.62	0.72	92.3
Column #2 T_6	314.75	0.72	92.3
Column #3 T_6	0	-	0
Column #4 T_6	0	-	0
Column #5 T_6	312.39	0.72	91.4
Column #6 T_6	313.92	0.72	92.0

Tabulated Gas Chromatography Data for Verification of Ethylenediamine Degradation

Standard Curve Data

[EN] ppm	Peak area	R_t
0	0	-
1.8	7.20	0.75
5.4	11.72	0.74
18	35.89	0.73
54	195.70	0.73
108	317.63	0.72
180	601.40	0.72
270	836.49	0.74
360	910.70	0.71

Regression Output:

Constant (y axis intercept) 18.44
x coefficient (slope) 2.75
R squared 0.976

Ethylenediamine Degradation Data

Sample	Peak area	R_t	[EN] ppm
KAFB#1 T_0	308.72	0.75	105.2
KAFB#1 T_{18}	ND	-	<1
KAFB#2 T_0	297.47	0.72	101.1
KAFB#2 T_{18}	ND	-	<1
KAFB#3 T_0	323.75	0.71	110.7
KAFB#3 T_{18}	ND	-	<1
Control T_0	309.22	0.73	93.6
Control T_{18}	309.77	0.73	93.8

Percent Solids Calculation For Activated-Sludge

(Dry weight/Wet weight) * 100 = % Solids

This value is used to determine the amount of wet sludge pellet to add to the 3" X 57" PVC sludge column.

((2.5 grams Solids/liter)/(% Solids)) X 4 liters of dilution media = the amount of wet sludge which needs to be added to the column.

Wet sludge weight: 1.50 g
Dry sludge weight: 1.19 g

(1.19 g/1.5 g) * 100 = 79.3%

((2.5 g/L)/(0.793)) * 4 = 12.61 g wet sludge needs to be added.

Nutrient Feed Media

Compound	g/L
NH_4Cl	2.85
KH_2PO_4	1.14
$FeCl_3$	0.21
Carbon*	0.1

*The carbon source can be either phenol or glucose at 100 ppm.

Formulation for EPA Dilution Media and EPA Dilution Media Agar Plates

Solution Type	Compound	g/L
I	NH_4Cl	35
	KNO_3	15
	K_2HPO_4 $3H_2O$	75
	NaH_2PO_2 H_2O	25
II	KCl	10
	$MgSO_4$	20
	$FeSO_4$ $7H_2O$	1
Adjust to pH 3.0 with HCl		
III	$CaCl_2$	5
	$ZnCl_2$	0.05
	$MnCl_2$ $4H_2O$	0.5
	$CuCl_2$	0.05
	$CoCl_2$	0.001
	H_3BO_3	0.001
	MoO_3	0.0004
Agar*		15

*Agar is added to this formula if Agar Plates are desired.
Add 1 ml of solution I, II, and III to 1 liter DI water.
Store each solution separately in the refrigerator.

APPENDIX Q

AIR FORCE IMPLEMENTATION DOCUMENTS AND METALLUGICAL TEST RESULTS

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DEPARTMENT OF THE AIR FORCE
HEADQUARTERS SAN ANTONIO AIR LOGISTICS CENTER (AFLC)
KELLY AIR FORCE BASE, TEXAS 78241-5000

REPLY TO
ATTN OF: Kurt Greebon and Ray Martinez (EG&G Idaho Inc.)

SUBJECT: Non-Cyanide Stripper Implementation (Clepo-204 Nickel Stripper)

TO: Don Mercer

1. Clepo-204 stripper which is recommended for stripping nickel coatings from steel, copper, and brass basis metal parts was implemented at the SA-ALC Plating Shop on 15 August 90. This stripper was selected for this implementation for its basis metal protection, strip rate, its excellent rinse and in service life properties. It is highly recommended for use in lieu of cyanide and most other noncyanide nickel strippers.

2. During this implementation period 15 August - 30 October 90 a representative cross section of A/C Engine steel base metal parts which are currently stripped in this application were evaluated and are listed as cited below. Because of the excellent stripping properties of this stripper, after the first two weeks of the implementation evaluation, the strip line chemist approved the stripper for full production usage on a three shift basis. The Clepo stripper was evaluated with respect to strip rate, basis metal protection, regeneration and vapor emission properties in a production environment. The stripping conditions used for this evaluation were mechanical agitation and a solution temperature of 130 F $\pm$ 5 F. Control tests using laboratory analysis to correlate strip rates and basis metal protection were also performed.

Implementation Evaluation A/C Parts

F-100 A/C Engine Parts:

Bearing Scoops	- 43 each
Shafts	- 27 "
Sun Gears	- 11 "

T-56 Engine Parts:

Compressor Cases	- 39 each
Tie Bolts, short	- 36 "
Tie Bolts, long	- 8 "
Lock Prop. T Brg.	- 10 "
Lock Prop. T Nuts	- 29 "

B-52 Engine Parts:

Links-------------- 60 each

Cones-------------- 15 "

Lock Pins---------- 10 "

Supports----------- 8 "

Brackets----------- 5 "

3. During the evaluation period the stripper solution pH was tested on a daily basis at first and then on a weekly basis when it was determined that the solution pH was fairly stable even under production usage. Periodic strip rate and basis metal protection tests were performed to correlate results between test coupons and A/C parts being stripped. The initial strip rates for this stripper of four mils per hour supported the quick approval for the full production acceptance as mentioned above in paragraph two. At the end the implementation period the strip rate still remained acceptable for production usage and for this reason regeneration of this stripper was not accomplished. The basis metals protection on A/C engine parts evaluated during this implementation was very satisfactory and these results correlated well with laboratory coupon test results which were run on a 24 hour basis. No odor or vapor emission problems were encountered.

4. Based on this implementation evaluation results, Clepo-204 Nickel Stripper can be used in Air Force Plating Shops for production applications requiring the stripping of sulfamate Nickel from steel base metal A/C engine parts at lower operating temperatures (125 - 135 F). The benefits that can be realized by the Air Force by the use of this stripper are better worker safety and less waste generation because of the stripper stability which results in longer usage life.

Kurt Greebon

KURT GREEBON
CHEMIST

Ray Martinez

RAY MARTINEZ
CHEMIST

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS SAN ANTONIO AIR LOGISTICS CENTER (AFLC)
KELLY AIR FORCE BASE, TEXAS 78241-5000

REPLY TO
ATTN OF: KURT GREEBON AND RAY MARTINEZ (EG&G Idaho, Inc.)

SUBJECT: Non-Cyanide Stripper Implementation
(Clepo-204 Nickel Stripper and Nickel-Sol Process)

TO: Don Mercer

1. During the implementation evaluation of subject stripper a request by Don Mercer, Supervisor of the plating shop laboratory, was made concerning the effects of CLEPO-204 Stripping solution on Chromium coatings. This request was made to determine if the present practice of applying a wax mask over the Chromium coating can be eleminated on A/C parts which need to be stripped of Nickel.

2. Several test coupons were plated, some with Chromium only and some with Chromium & Nickel plated adjacent to each other. These coupons were then used to perform Chromium basis metal protection tests. The Chromium plated coupons (2 ea) were used to perform a 25 Hr base metal protection test. The results of this test revealed that no significant mass change occured. The Chromium and plated coupons were tested at 6 and 18 Hr periods. The results revealed that no detrimental effects occured on the Chromium plated areas. Microscopic examination on all the above tests coupons failed to reveal any detrimental effects on the Chromium plated surfaces. All test coupons used in these tests including a reference coupon will be turned over to Kurt Greebon for the purpose of metalurgical analysis if deemed necessary.

3. Based on the results of the above tests it is not necessary to apply masking material over the Chromium plated surfaces of the parts which are required to be stripped in CLEPO-204 Nickel stripper.

4. Request that action be taken to accomplish the following:

A. That the necessary procurment action be taken to purchase additional supply of CLEPO-204 Nickel stripper for its continued use.

B. That a larger strip tank be made available to utilize the remaining stock of the Nickel-Sol process Nickel stripper. Sufficient quantities are available for a 500 gallon operating volume solution which would allow for a more suitable production utilization. This size of operating volume will allow stripping of the large F-100 Augmentor liners.

Kurt Greebon
Kurt Greebon
Chemist

Ray Martinez
Ray Martinez
Chemist

AFLC COMBAT STRENGTH THROUGH LOGISTICS

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS SAN ANTONIO AIR LOGISTICS CENTER (AFLC)
KELLY AIR FORCE BASE, TEXAS 78241-5000

REPLY TO ATTN OF: Kurt Greebon and Ray Martinez (EG&G Idaho Inc.)

SUBJECT: Non-Cyanide Stripper Implementation (Nickel-Sol Process)

TO: Don Mercer

1. Nickel-Sol Process stripper which is recommended for stripping nickel coatings from stainless steel basis metal parts was implemented at the SA-ALC Plating Shop on 16 July 90. This stripper was selected for this implementation for its basis metal protection, strip rate, less hazardous to workers use and less waste generation properties. It is highly recommended for use in lieu of the presently used Nitric acid for nickel coating stripping applications.

2. During this implementation period 16 July 90 - 13 September 90 a representative cross section of A/C Engine parts which are currently stripped in the Nitric acid stripper were evaluated and are listed below. The Nickel-Sol stripper was evaluated with respect to strip rate, basis metal protection, regeneration and vapor emission properties in a production environment. Control tests using laboratory analysis to correlate results were also performed. Metallurgical analyses of some basis metals were also performed to verify the basis metal protection of subject stripper on Inconel-X750 and Titanium metals. This stripper evaluation was conducted at ambient temperature using air sparge for solution agitation.

Implementation Evaluation A/C Parts

F-100 A/C Engine Parts:

Variable Vanes:

4th stage	248 each
5th stage	326 "
Inlet guide	340 "

Sync Rings:

4th stage	7 each
5th stage	8 "
Inlet guide	4 "

Combustion Chambers:

I. D.	2
O. D.	2

GT Engine Parts:

Nozzle Assy	2
Scoops	5

3. During the evaluation period the stripping solution was analyzed on a weekly basis due to the fact that usage was limited because of the small operating volume. Regeneration of the bath proved to be satisfactory to maintain strip rates of 1 mil per hour or better for the electroless (phosphorous) nickel coatings and 2 mils per hour or better for the electrolytic (sulfamate) nickel coatings. No vapor emission or fume odor problems were experienced. Basis metal protection for the stainless and titanium parts was found to be satisfactory. At the request of the laboratory process chemist, Rudy Muniz, metallurgy analyses were performed by the SA-ALC Metallurgical Laboratory on four(4) and eight (8) hour exposed F-100 engine 5th staged variable vane sections. The results obtained by the Metallurgical Laboratory failed to find any detrimental effects on the I-X750 basis metal. Because the stripping of nickel off titanium vanes is another required application for this implementation stripper it was decided by EG & G, Inc, Ray Martinez and SA-ALC, Kurt Greebon chemists to have metallurgical analyses performed on these base metals. The results obtained by the SA-ALC/MAQCM Metallurgical Laboratory on the 4 & 8 hour exposed F-100 Engine Inlet Guide Vane sections were negative, as per attached MAQCM report results. Due to high humidity in the shop and the insufficient rinsing of some of the Inlet Guide Vanes, a wet film was found to form on the vanes. It is therefore recommended that a minimum of 10 minutes cold rinse be followed by a 5 minute minimum hot rinse be used when using this stripper. Because of the operating volume (100 gals) limitation, the F-100 Augmentor liners could not be stripped. Laboratory evaluation tests of the liner coating specimen found that this is as good as the Nitric Stripper in removing this liner coating.
4. Based on this implementation evaluation results the Nickel-Sol process stripper can be used in lieu of the presently used 50% by volume Nitric Acid stripper. The benefits that can be realized by the Air Force by use of this process stripper are worker safety (less hazardous stripper from the stand point of the elimination of NOx fumes) and less chemical waste generation because the Nickel-Sol stripper can be regenerated to eliminate the current waste of 6000 gal per year.

Kurt Greebon
KURT GREEBON
CHEMIST

Ray Martinez
RAY MARTINEZ
CHEMIST

LABORATORY ANALYSIS REPORT			1. DATE 16 AUG 1990
2. TO MAEIC/K. Greebon/53190	3. FROM SA-ALC/MAQCM	4. FOR ADDITIONAL INFORMATION, CONTACT (Name and AUTOVON / Phone No) C. Serafini/57741	
5. ITEM / SAMPLE IDENTITY Inlet Guide Vanes			6. DATE RECEIVED
7. ITEM / SAMPLE SOURCE OR END ITEM APPLICATION F-100 Engine			8. LAB CONTROL NO 90-0943
9. TYPE OF ANALYSIS REQUESTED Microstructural Examination			10. STORAGE LOCATION NO

1. Portions of four inlet guide vanes used on the F-100 engine were submitted to the Metallurgical Science Section (MAQCM) for a surface and microstructural examination investigating any detrimental effects.

2. Mounted microsections were made through each of the four IGV's airfoil areas. Surface areas were examined and optical micrographs were made (photos, 1-4).

3. Results: No intergranular attack, detrimental etching or other metallurgical deficiencies were observed.

Charles Serafini
Metallurgist

MARCOS R. SOLIS, Chief
Metallurgical Science Section

SA-ALC FORM H-5, APR 84 (Formerly AFLC Form 4133, Apr 84, which will be used)

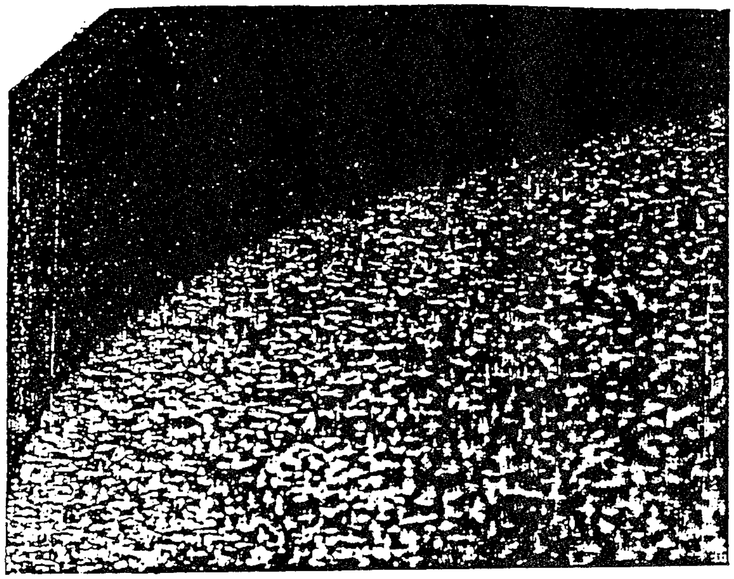

PHOTO 1:

Optical micrograph of a section of the blade marked #1.

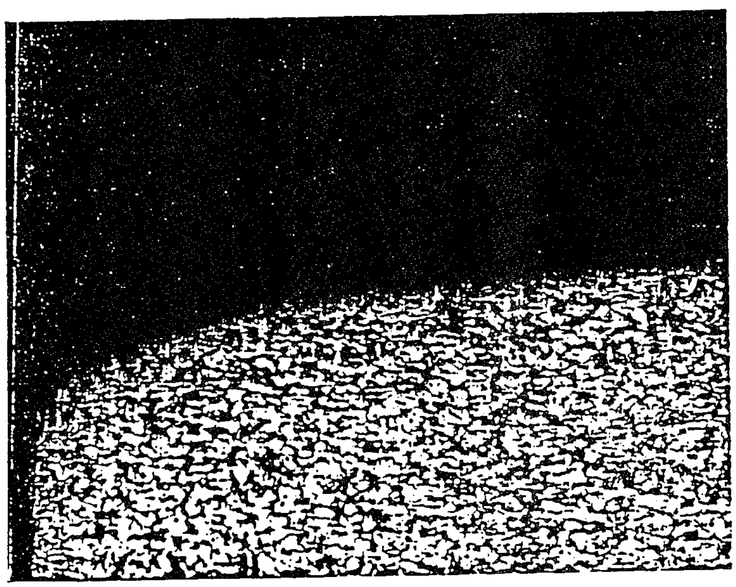

PHOTO 2:

Optical micrograph of a section of the blade marked #2.

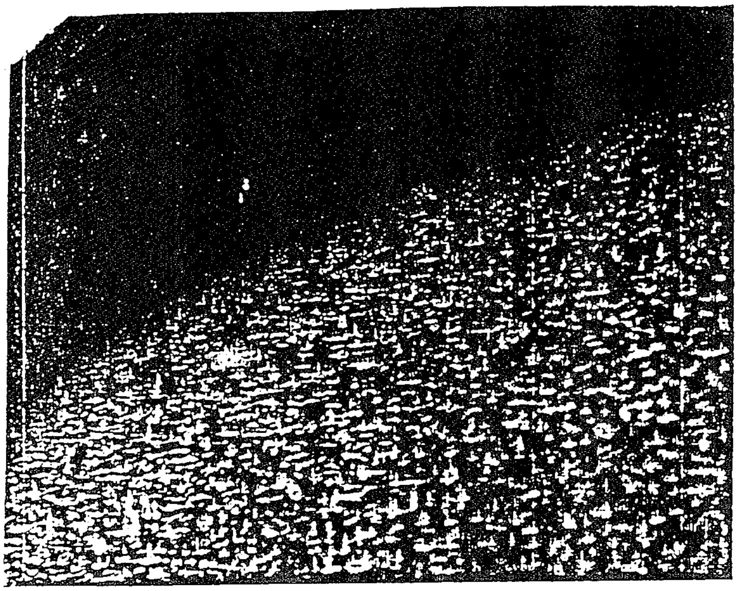

PHOTO 3:

Optical micrograph of a section of the blade marked #3.

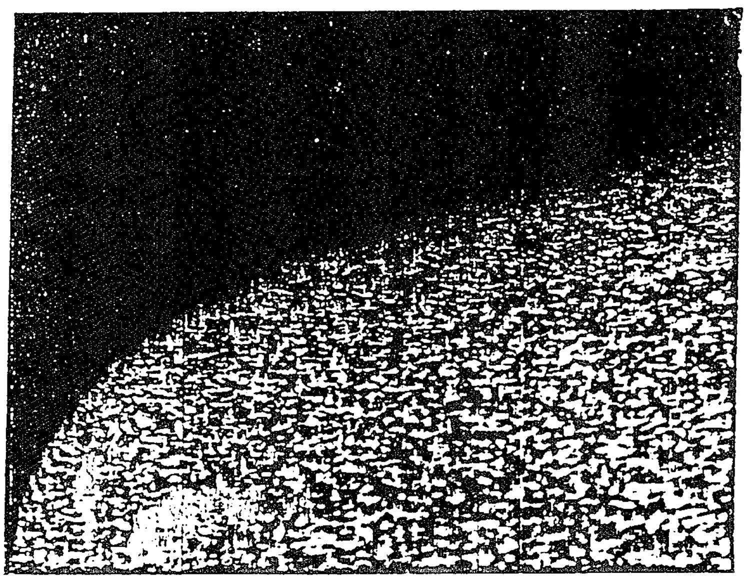

PHOTO 4:

Optical micrograph of a section of the blade marked #4.

APPENDIX R

SAMPLE TECHNICAL ORDER IMPROVEMENT REPORTS

(AFTO 22 FORMS)

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☆ U.S. GOVERNMENT PRINTING OFFICE: 1974—659-194

TECHNICAL ORDER SYSTEM PUBLICATION IMPROVEMENT REPORT AND REPLY

FORM APPROVED OMB NO. 21-R0207

1. TO: (Major Command or equivalent)	2. TO: (Orgn having Mgmt Responsibility for the T.O.)	3. FROM (Orgn reporting)	4. REPORT DATE YR MO DAY
SA-ALC	TIRTA/SFTT	LPPTAH	9 0 1 1 0 1

5. BASIC DATE OF T.O.	6. DATE OF T.O. CHANGE	7. PAGE NUMBER	8. PARAGRAPH NUMBER	9. FIGURE NUMBER
15 Mar. 79	1 Sept. 89	12-4	12-7	Table 12-1 Step 3

DOC IDENT	TO	FROM	TECHNICAL ORDER NUMBER	IMPROVEMENT REPORT NUMBER
1 2 3	4	5	6–30	31–45
X Y A	H	4	2C 2- 1 -7	

10. BRIEF SUMMARY OF DEFICIENCY AND RECOMMENDED CHANGE (Use continuation sheets if necessary)

Deficiency:

The currently cited stripper solution, C-106, for removing electrolyic nickel from steel contains sodium cyanide, 10 to 14 ounces per gallon, as one of the formulation ingredients. This stripper, because it contains sodium cyanide, is toxic and if accidently mixed with an acid it can produce a very toxic or lethal hydrocyanic acid. In addition, because of its short service life, large volumes of waste are generated by its use. This waste is difficult to treat by industrial waste treatment facilities and must at times be disposed of by contractors.

Recommendation:

It is recommended that nickel cyanide stripper solution, C-106, cited in Step 3 of Table 12-1 be replaced by Clepo 204, a noncyanide nickel stripper that has superior properties such as strip rates, longer service life that will result in less waste generation, and is a safer solution which will provide a better working environment. This product was implemented at the SA-ALC plating shop in August 1990 on an Air Force contract by EG&G Idaho, Inc. This Air Force coordinated (continued)

11. REPORTED BY (Initiator's Signature, OAS and Extension)	12. APPROVED BY (Supervisor's Signature)	13. QUALITY CONTROL (Signature)

14. MAJOR COMMAND ACTION	15. (Check applicable block) ☐ APPROVED ☐ DISAPPROVED	16. SIGNATURE (Major Command Authority)	17. DATE

☐	TR CODE (46–48)	DATE RECEIVED YR MO DAY (49–54)	DATE TO MGR YR MO DAY (55–60)	MGR (61)	TRANSFER CODE (62–66)	DOWN-GRADED (67)	(Reserved) (68–80)
	D A A						

☐	TR CODE (46–48)	DATE FROM MGR YR MO DAY (49–54)	ACTION TAKEN (55–66)	RESOLUTION DATE YR MO DAY (67–72)	(Reserved) (73–80)
	D B A				

18. TO: (Major Command or equivalent)	19. TO: (Organization Reporting Improvement)	20. FROM (SM/IM)

21. REMARKS (Use continuation sheets if necessary)

22. DATE OF REPLY	23. REPLY BY (Signature, OAS, Extension)	24. APPROVED BY (Supervisor)

AFTO FORM APR 73 22 — REPLACES AFTO FORMS 22 AND 22A WHICH ARE OBSOLETE

Continuation Sheet

Clepo 204 Nickel Stripper

Recommendation: (Continued)
implementation study revealed that this product is very satisfactory for this application.

This product, Clepo 204, is manufactured by Grederick Gumm Chemical Company, Inc., 538 Forest Street, Kearny, NJ 07032, Phone # 800-223 GUMM.

Operating Conditions: Stripper Components Concentration
Clepo 204N-------------33% by Volume
Clepo 204T------------- 8 ounces per gallon
Water------------------ to operating volume
Operating Temperature Range--- 125-135 F
Operating pH Range------------ 10-10.5
Solution Agitation-- Mechanical Impeller

Solution Preparation:

1. Add water to one half the operating volume level.
2. Add 33% by volume of the Clepo 204 N, start mechanical agitator and allow to mix thoroughly.
3. Add 8 ounces per gallon of Clepo 204 T and allow to mix thoroughly.
4. Add water to the level of the final operating volume.
5. Do not heat solution till ready to conduct stripping operation.

☆ U.S. GOVERNMENT PRINTING OFFICE: 1974-659-194

TECHNICAL ORDER SYSTEM PUBLICATION IMPROVEMENT REPORT AND REPLY

FORM APPROVED
OMB NO. 21-R0207

1. TO: (Major Command or equivalent)	2. TO: (Orgn having Mgmt Responsibility for the T.O.)	3. FROM (Orgn reporting)	4. REPORT DATE YR MO DAY
SA-ALC	TIRTR/SFTT	LPPTAH	90 11 01

5. BASIC DATE OF T.O.	6. DATE OF T.O. CHANGE	7. PAGE NUMBER	8. PARAGRAPH NUMBER	9. FIGURE NUMBER
15 Mar. 79	1 Sept. 89	13-3	13-7	Table 13-1, Step 3

DOC IDENT (1-3)	TO (4)	FROM	TECHNICAL ORDER NUMBER (5-34)	IMPROVEMENT REPORT NUMBER (35-45)
XYA	H		42C2-1-7	

10. BRIEF SUMMARY OF DEFICIENCY AND RECOMMENDED CHANGE (Use continuation sheets if necessary)

Deficiency:

The currently referenced stripper solution, C-120, for stripping electroless nickel coating from stainless steel is nitric acid. While nitric acid is a very good stripper, its use has disadvantages. The problems associated with this solution are the release of noxious (NOx) fumes which are not condusive to a safe working environment and the generation of large volumes of heavy metals laden acid waste.

Recommendation:

Recommend that an alternate stripper, Nickel-Sol Process solution, be cited for use in applications requiring the stripping of electroless nickel from stainless steel parts. The advantages with the use of this solution are the absence of noxious fumes, and waste generation will be minimal because this strip solution can be regenerated for extended use. This product was implemented at the SA-ALC plating shop in July 1990 on an Air Force contract by EG&G Idaho, Inc. An Air Force coordinated implementation evaluation study revealed that this stripper solution is satisfactory for this application. (Continued)

11. REPORTED BY (Initiator's Signature, OAS and Extension)	12. APPROVED BY (Supervisor's Signature)	13. QUALITY CONTROL (Signature)

14. MAJOR COMMAND ACTION	15. (Check applicable block) ☐ APPROVED ☐ DISAPPROVED	16. SIGNATURE (Major Command Authority)	17. DATE

	TR CODE (46-48)	DATE RECEIVED YR MO DAY (49-54)	DATE TO MGR YR MO DAY (55-60)	MGR (61)	TRANSFER CODE (62-66)	DOWN-GRADED (67)	(Reserved) (68-80)
☐	DAA						

	TR CODE (46-48)	DATE FROM MGR YR MO DAY (49-54)	ACTION TAKEN (55-66)	RESOLUTION DATE YR MO DAY (67-72)	(Reserved) (73-80)
☐	DBA				

18. TO: (Major Command or equivalent)	19. TO: (Organization Reporting Improvement)	20. FROM (SM/IM)

21. REMARKS (Use continuation sheets if necessary)

22. DATE OF REPLY	23. REPLY BY (Signature, OAS, Extension)	24. APPROVED BY (Supervisor)

AFTO FORM APR 73 22 REPLACES AFTO FORMS 22 AND 22A WHICH ARE OBSOLETE

Continuation Sheet

Nickel-Sol Nickel Stripper

Recommendation: (Continued)

This product is manufactured by Electrochemicals, Inc., 751 Elm Street, Youngstown, Ohio 44502. Phone # 800-321-9050.

Operating Conditions:

Stripper Components:

Nickel-Sol I----------------	10-12% by volume
Sulfuric Acid (66 Baume)----	10-20% by volume
NPA Stabilizer--------------	10% by volume
NPB Stabilizer--------------	1.5% by volume
Copper Sulphate 5 H20	2.0 oz. per/gal.

Operating Temperature - Ambient Temperature Only
Solution Agitation Method - By Air or Mechanical Impeller

Solution Preparation:

1. Add water to 50% of the final Working volume.
2. Add the required amount of copper Sulphate. 5H20
3. While mixing, slowly add the required amount of 66 Baume sulfuric acid. Do not allow solution temperature to exceed 140°F.
4. Add required amount of NPA and NPB stabilizers.
5. Add the required amount of Nickel-Sol I (50% Hydrogen Peroxide).
6. If necessary, add water to make up the balance of the operating bath volume.

Note: For additional information refer to product bulletin.

☆ U.S. GOVERNMENT PRINTING OFFICE: 1974—659-194

TECHNICAL ORDER SYSTEM PUBLICATION IMPROVEMENT REPORT AND REPLY

FORM APPROVED OMB NO. 21-R0207

1. TO: *(Major Command or equivalent)*	2. TO: *(Orgn having Mgmt Responsibility for the T.O.)*	3. FROM *(Orgn reporting)*	4. REPORT DATE YR / MO / DAY
SA-ALC	TIRTR/SFTT	LPPTAH	9 0 / 1 1 / 0 1

5. BASIC DATE OF T.O.	6. DATE OF T.O. CHANGE	7. PAGE NUMBER	8. PARAGRAPH NUMBER	9. FIGURE NUMBER
15 Mar. 79	1 Sept. 89	13-3	13-7	Table 13-1,Step 3

DOC IDENT	T O	FROM	TECHNICAL ORDER NUMBER	IMPROVEMENT REPORT NUMBER
X Y A	H	4	2 C 2 - 1 - 7	

10. BRIEF SUMMARY OF DEFICIENCY AND RECOMMENDED CHANGE *(Use continuation sheets if necessary)*

Deficiency:

The currently cited stripper solution, C-106, for removing electroless nickel coatings contains sodium cyanide, from 10 to 14 oz. per gallon, as one of the formulation ingredients. The stripper, because it contains sodium cyanide, is toxic and if accidently mixed with an acid will produce highly toxic hydrocyanic acid. In addition, large volumes of waste are generated because it has a short service life. This waste is difficult to treat by industrial waste treatment facilities and at times disposal by contractor is the only alternative.

Recommended change:

Recommend that nickel cyanide stripper, C-106, cited in Step No. 3 of Table 13-1 be replaced by Metalx B-9. A noncyanide nickel stripper, that has a superior stripping rate, a longer service life and is safer to use. This stripper has been tested by EG&G Idaho, Inc. on an Air Force contract and found to be satisfactory for this application.

(Continued)

11. REPORTED BY *(Initiator's Signature, OAS and Extension)*	12. APPROVED BY *(Supervisor's Signature)*	13. QUALITY CONTROL *(Signature)*

14. MAJOR COMMAND ACTION	15. *(Check applicable block)* ☐ APPROVED ☐ DISAPPROVED	16. SIGNATURE *(Major Command Authority)*	17. DATE

☐	TR CODE (46-48)	DATE RECEIVED YR MO DAY (49-54)	DATE TO MGR YR MO DAY (55-60)	MGR (61)	TRANSFER CODE (62-66)	DOWN-GRADED (67)	(Reserved) (68-80)
	D A A						

☐	TR CODE (46-48)	DATE FROM MGR YR MO DAY (49-54)	ACTION TAKEN (55-66)	RESOLUTION DATE YR MO DAY (67-72)	(Reserved) (73-80)
	D B A				

18. TO: *(Major Command or equivalent)*	19. TO: *(Organization Reporting Improvement)*	20. FROM *(SM/IM)*

21. REMARKS *(Use continuation sheets if necessary)*

22. DATE OF REPLY	23. REPLY BY *(Signature, OAS, Extension)*	24. APPROVED BY *(Supervisor)*

AFTO FORM APR 73 22 — REPLACES AFTO FORMS 22 AND 22A WHICH ARE OBSOLETE

Continuation Sheet

Metalx B-9 and Ni-plex 100 Nickel Strippers:

Recommendation: (Continued)

Also recommended to be included as an alternate stripper for this application is Ni-Plex 100 nickel stripper. This product was also tested in the above field optimization study and found to be satisfactory.

These products are manufactured by the following companies:

Metalx B-9 Nickel Stripper Metalx, Inc. RT., Box 683 Lenoir, N. C. 28645 Phone: Toll Free 1-800-752-7649	Ni-plex 100 Stripper M&T Chemicals, Inc. Rathway, New Jersey 07065-0970 Phone: (201) 499-0200

Operating Conditions:

Stripper concentration - These one component strippers can be used in either a Batch Method at 2.5 pounds per gallon or by an Addition Method at 1.5 pounds per gallon.

Operating Temperature Range---------- 120-150°F
Operating pH range, Metalx B-9------- 9.2-9.8
Ni-plex 100------ 8.5-10.5
Method of Agitation - Mechanical Impeller, Air (gentle) or pump circulation.

Solution Preparation:

1. Add water to a 50% level of the operating tank volume.
2. Heat solution to 120°F.
3. Add the required amount (1.5 or 2.5 pounds) of stripper compound.
4. Start agitation system and allow compound to completely dissolve.
5. Determine pH of the solution and if below the range, adjust pH value to the required range with small additions of soda ash. Note - If production flow allows, turn off heat when solution is not being used.

For additional information refer to product bulletins.